PROBLEMS IN GRAPHIC STATICS

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REMOTE STORAGE

P R O B L E M S

in

G R A P H I C S T A T I C S

by

Junior Class

Civil Engineering Department

University of Illinois

Universal Exposition

St. Louis

1904

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7 Aug. '18 Spencer

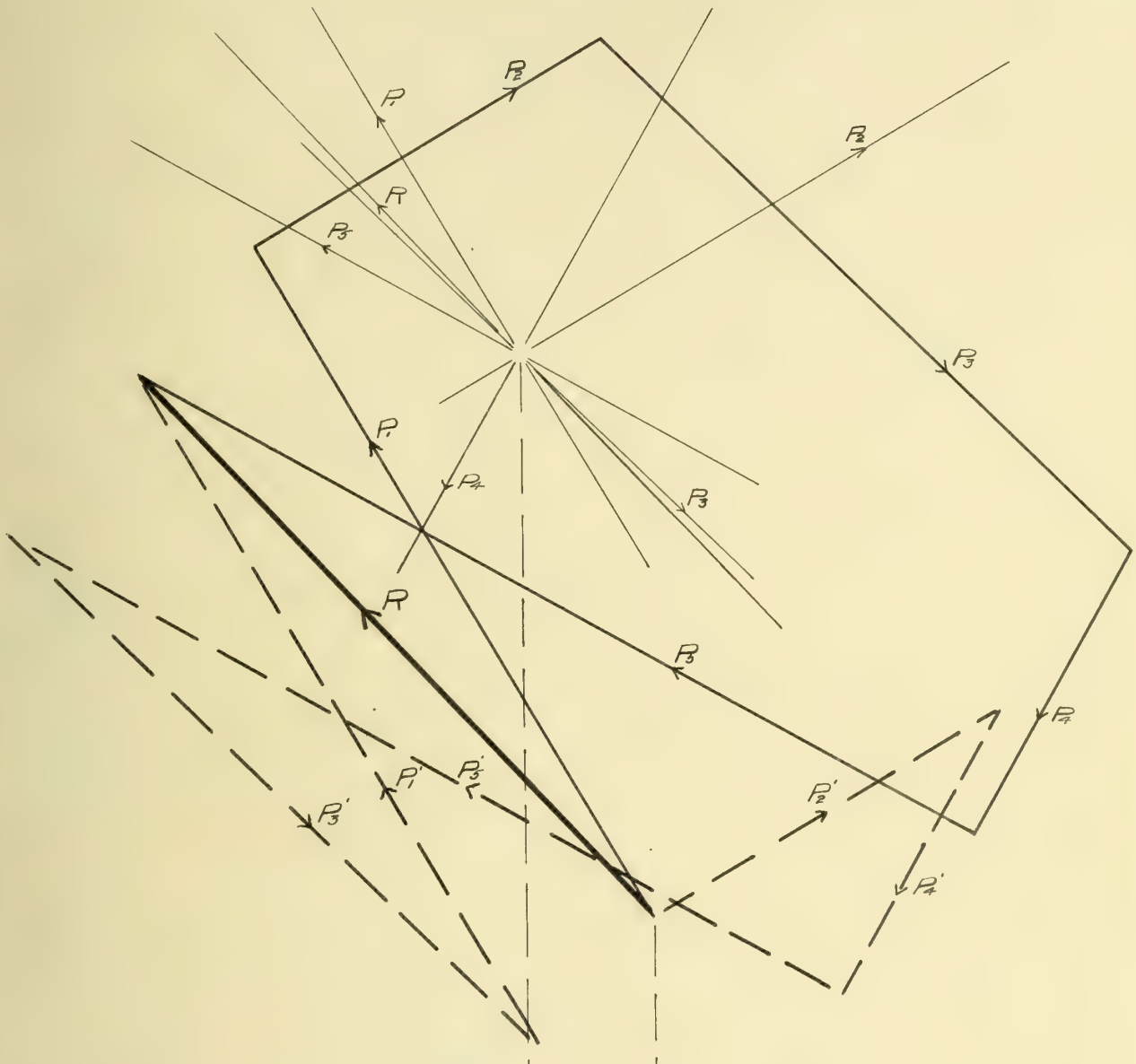
EXPLANATORY NOTE

These are the problems solved by the students in Graphic Statics during the second semester of the Junior year of the Civil Engineering Course. Two recitations per week are devoted to this subject. The students have previously given a semester, five recitations per week, to Analytical Mechanics, and when taking Graphic Statics are giving three recitations per week to Mechanics of Materials.

390681

GRAPHIC STATICS

PROBLEM 1.



Given.- P_1 1900# 120° P_2 930# 30°

P_3 1700# 315° P_4 750# 240° P_5 2200# 150°

To Find R.

Scale for force polygon 1" = 400#

$R = \overline{(\Sigma x)^2 + (\Sigma y)^2}^{1/2}$

$\Sigma x = P_1 \cos 120° + P_2 \cos 30° + P_3 \cos 315° + P_4 \cos 240° + P_5 \cos 150° = 1172.8\#$

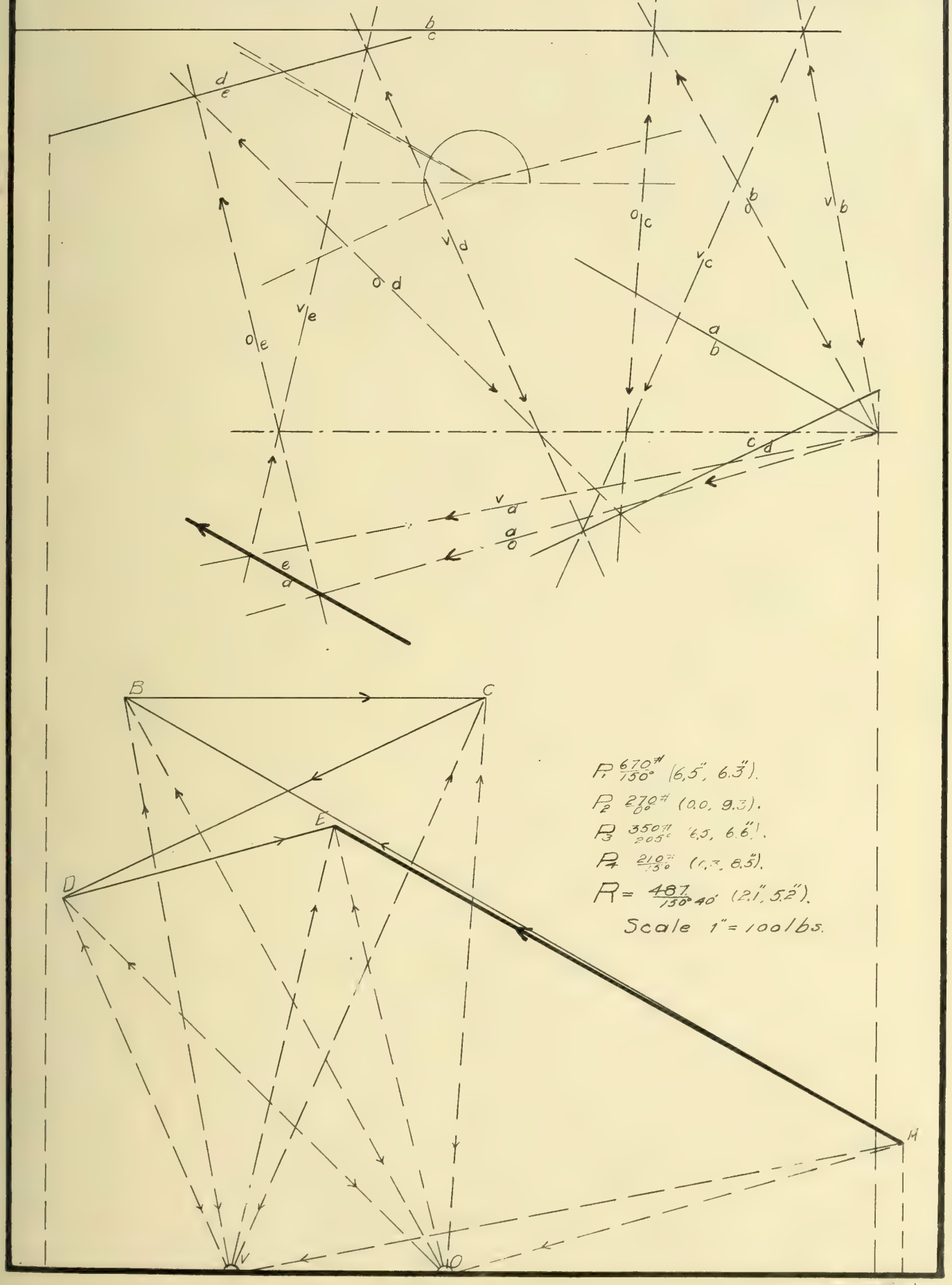
$\Sigma y = P_1 \sin 120° + P_2 \sin 30° + P_3 \sin 315° + P_4 \sin 240° + P_5 \sin 150° = 1272.2\#$

$R = \frac{1730\#}{132°40'}$ algebraically.

$R = \frac{1730\#}{133°30'}$ graphically.

F. I. Blair.

GRAPHIC STATICS. PROBLEM 2.



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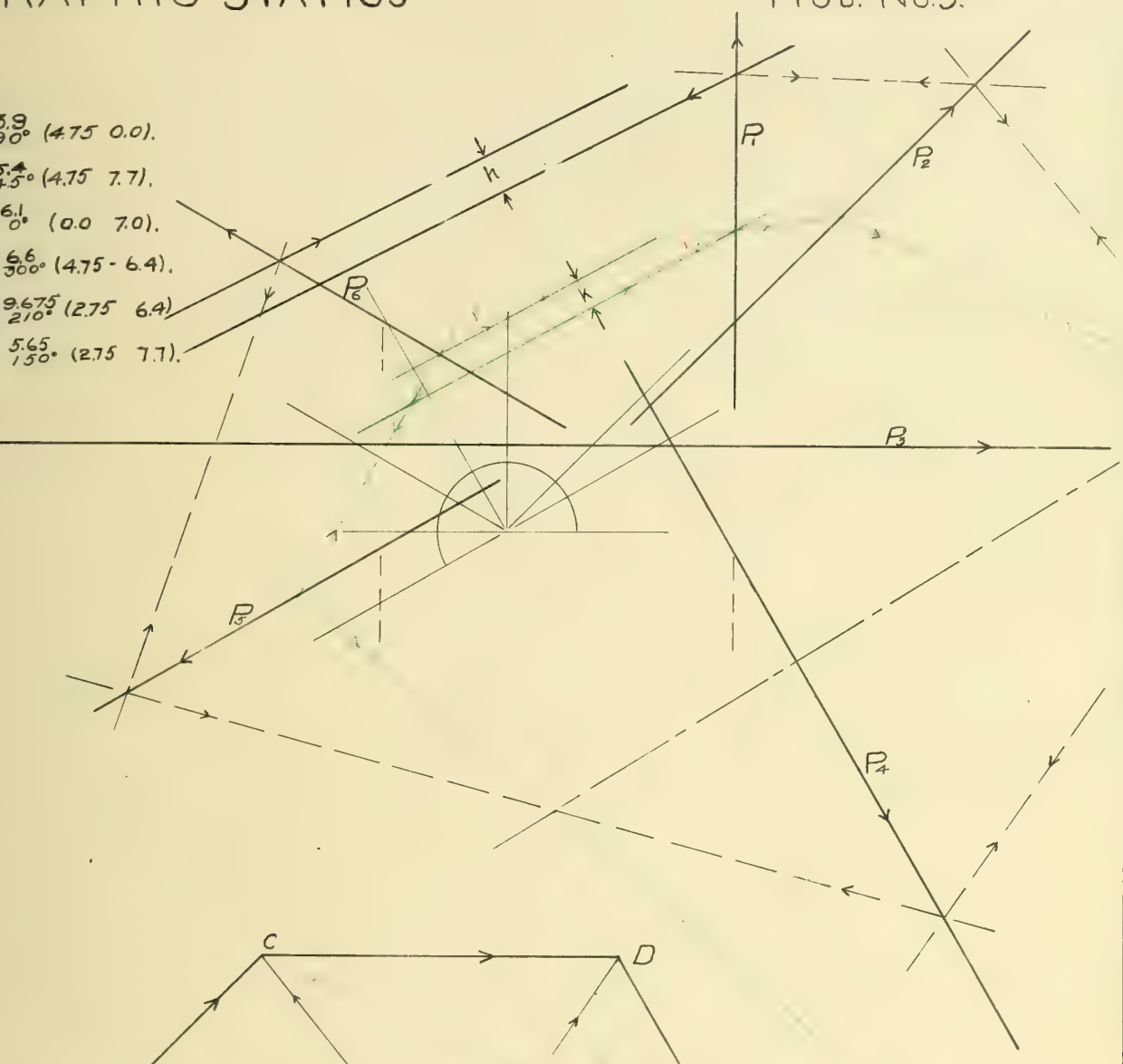
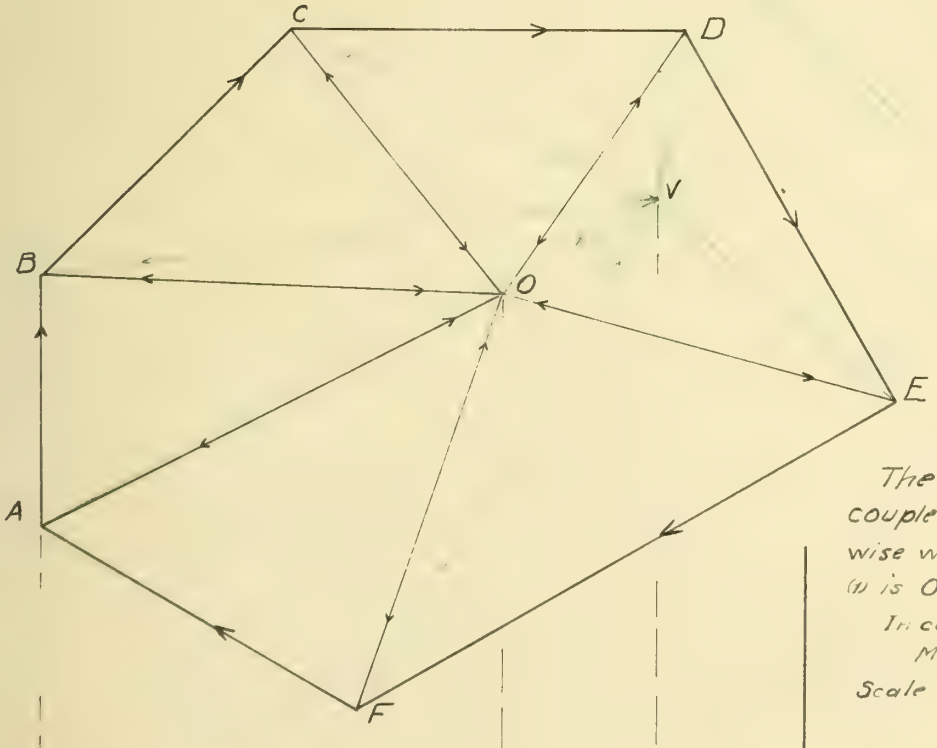
GRAPHIC STATICS

Prob. No. 3.

R_1 3.9 90° (4.75 0.0).
R_2 5.4 45° (4.75 7.7).
R_3 6.1 0° (0.0 7.0).
R_4 6.6 300° (4.75 - 6.4).
R_5 9.675 210° (2.75 6.4).
R_6 5.65 150° (2.75 7.7).





The equilibrant is the couple acting ~~anti~~ clockwise whose moment in case (1) is OA · h" = −1.76 Tons in.

In case (2)
Moment = VA · k" = 1.73 Ton.in.

Scale 1" = 3 Tons

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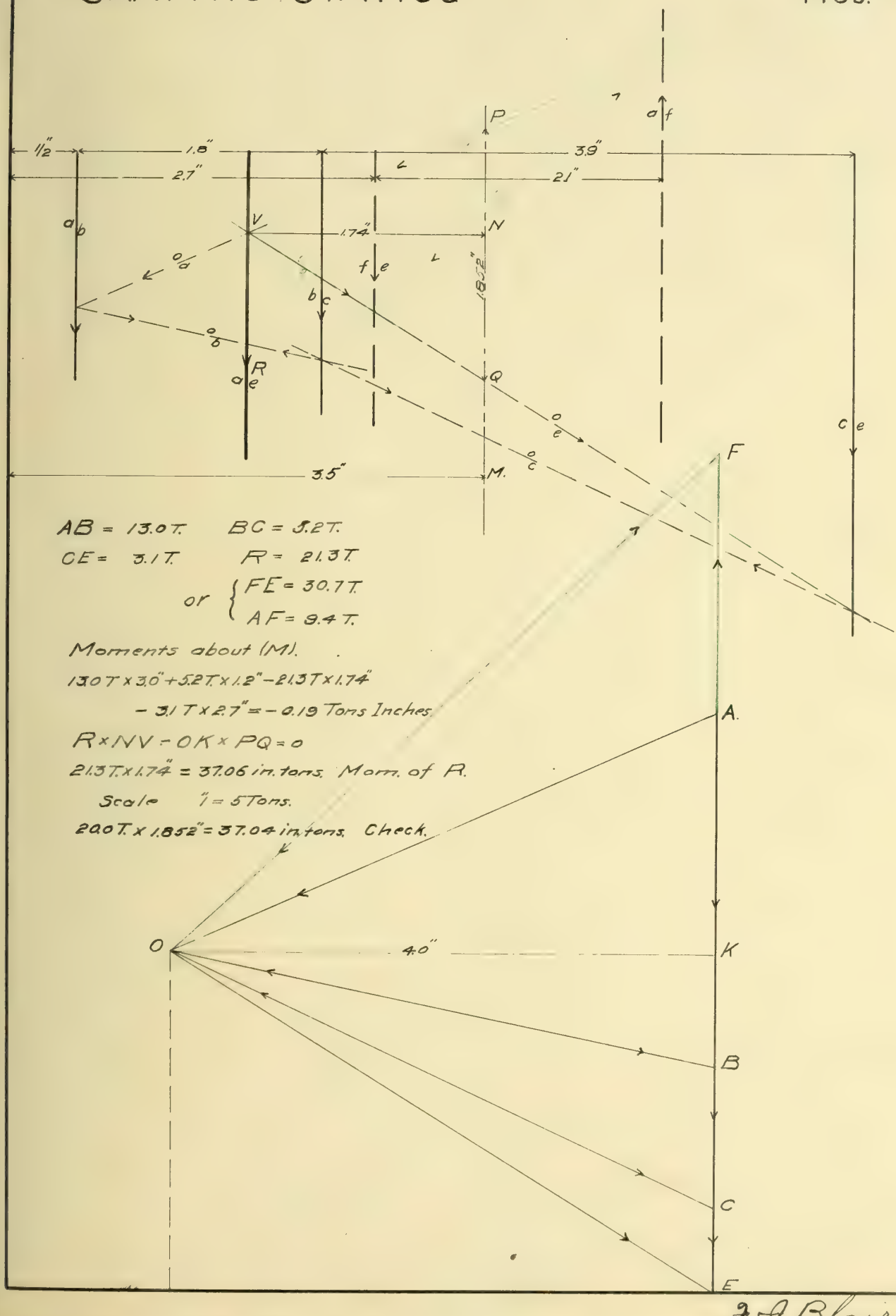
GRAPHIC STATICS

Prob. 4.



AB = 13.0 T. BC = 5.2 T.

CE = 3.1 T. R = 21.3 T.

or { FE = 30.7 T.
AF = 9.4 T.

Moments about (M).

13.0 T × 3.0" + 5.2 T. × 1.2" − 21.3 T × 1.74"

− 3.1 T × 2.7" = − 0.19 Tons Inches.

R × NV − OK × PQ = 0

21.3 T. × 1.74" = 37.06 in. tons. Mom. of R.

Scale 1" = 5 Tons.

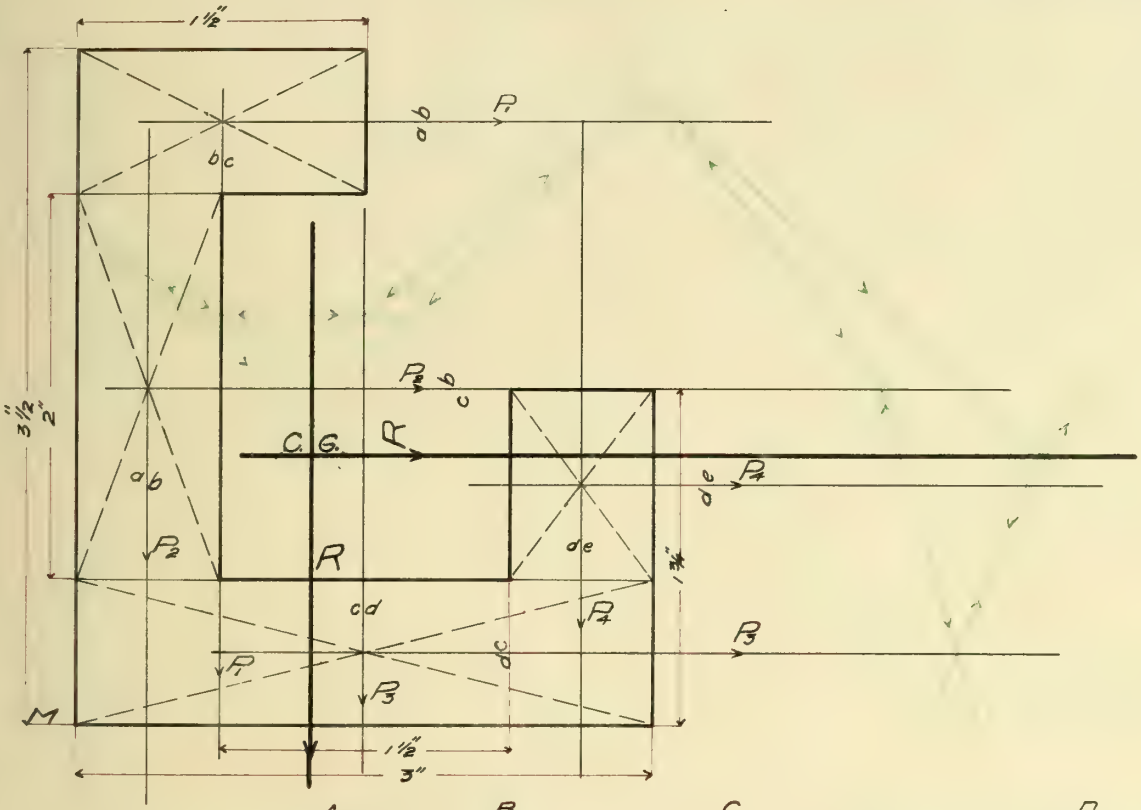
20.0 T. × 1.852" = 37.04 in. tons. Check.

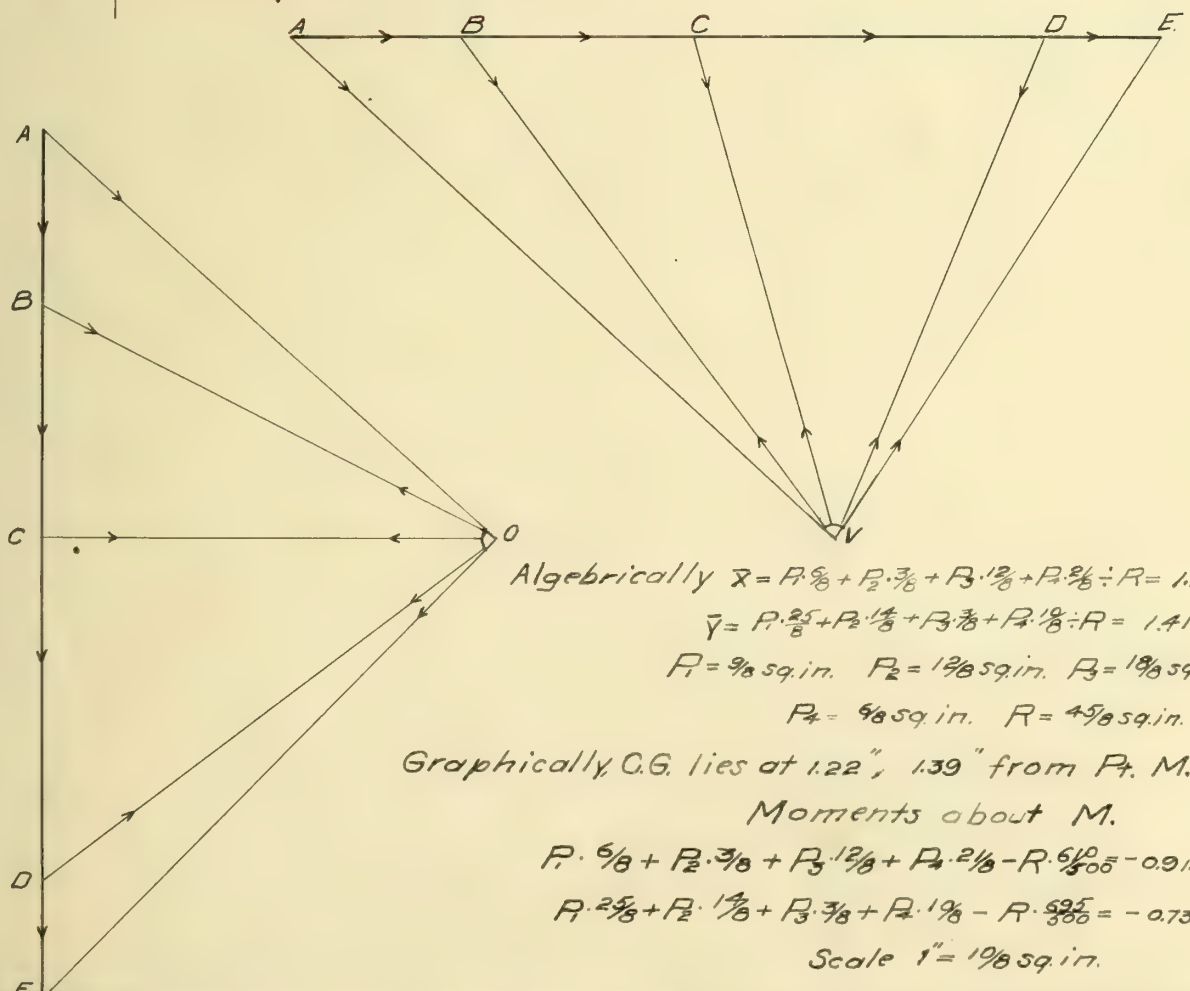
J. A. Blair.

MAR 7

GRAPHIC STATICS

Prob. 5.





Algebrically $\bar{x} = P_1 \cdot \frac{6}{8} + P_2 \cdot \frac{3}{8} + P_3 \cdot \frac{12}{8} + P_4 \cdot \frac{2}{8} \div R = 1.20"$

$\bar{y} = P_1 \cdot \frac{25}{8} + P_2 \cdot \frac{14}{8} + P_3 \cdot \frac{3}{8} + P_4 \cdot \frac{19}{8} \div R = 1.41"$

$P_1 = \frac{9}{8}$ sq. in. $P_2 = \frac{12}{8}$ sq. in. $P_3 = \frac{18}{8}$ sq. in.

$P_4 = \frac{6}{8}$ sq. in. $R = \frac{45}{8}$ sq. in.

Graphically, C.G. lies at 1.22", 1.39" from P_4. M.

Moments about M.

$P_1 \cdot \frac{6}{8} + P_2 \cdot \frac{3}{8} + P_3 \cdot \frac{12}{8} + P_4 \cdot \frac{2}{8} - R \cdot \frac{610}{500} = -0.9$ in. sq. in.

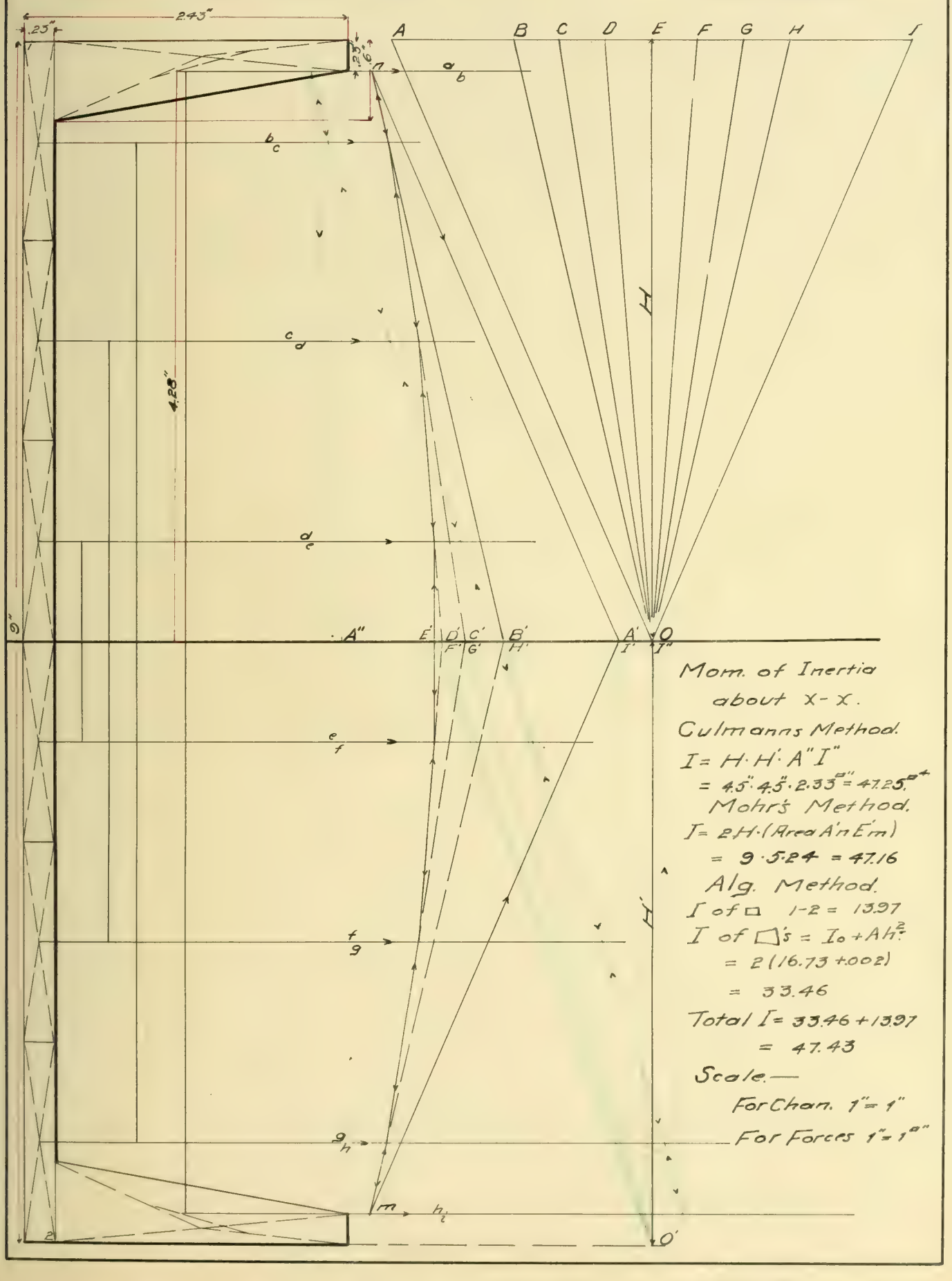
$P_1 \cdot \frac{25}{8} + P_2 \cdot \frac{14}{8} + P_3 \cdot \frac{3}{8} + P_4 \cdot \frac{19}{8} - R \cdot \frac{625}{500} = -0.73 \ldots$

Scale 1" = $\frac{10}{8}$ sq. in.

F. I. Blair.

GRAPHIC STATICS.

Prob. No. 6.



Mom. of Inertia about X-X.

Culmanns Method.

$I = H \cdot H' \cdot A''I''$

$= 4.5'' \cdot 4.5'' \cdot 2.33^{a''} = 47.25^{a''}$

Mohr's Method.

$I = 2H \cdot (\text{Area } A'nE'm)$

$= 9 \cdot 5.24 = 47.16$

Alg. Method.

I of □ 1-2 = 13.97

I of □'s = $I_o + Ah^2$

$= 2(16.73 + .002)$

$= 33.46$

Total $I = 33.46 + 13.97$

$= 47.43$

Scale.—

For Chan. 1" = 1"

For Forces 1" = $1^{a''}$

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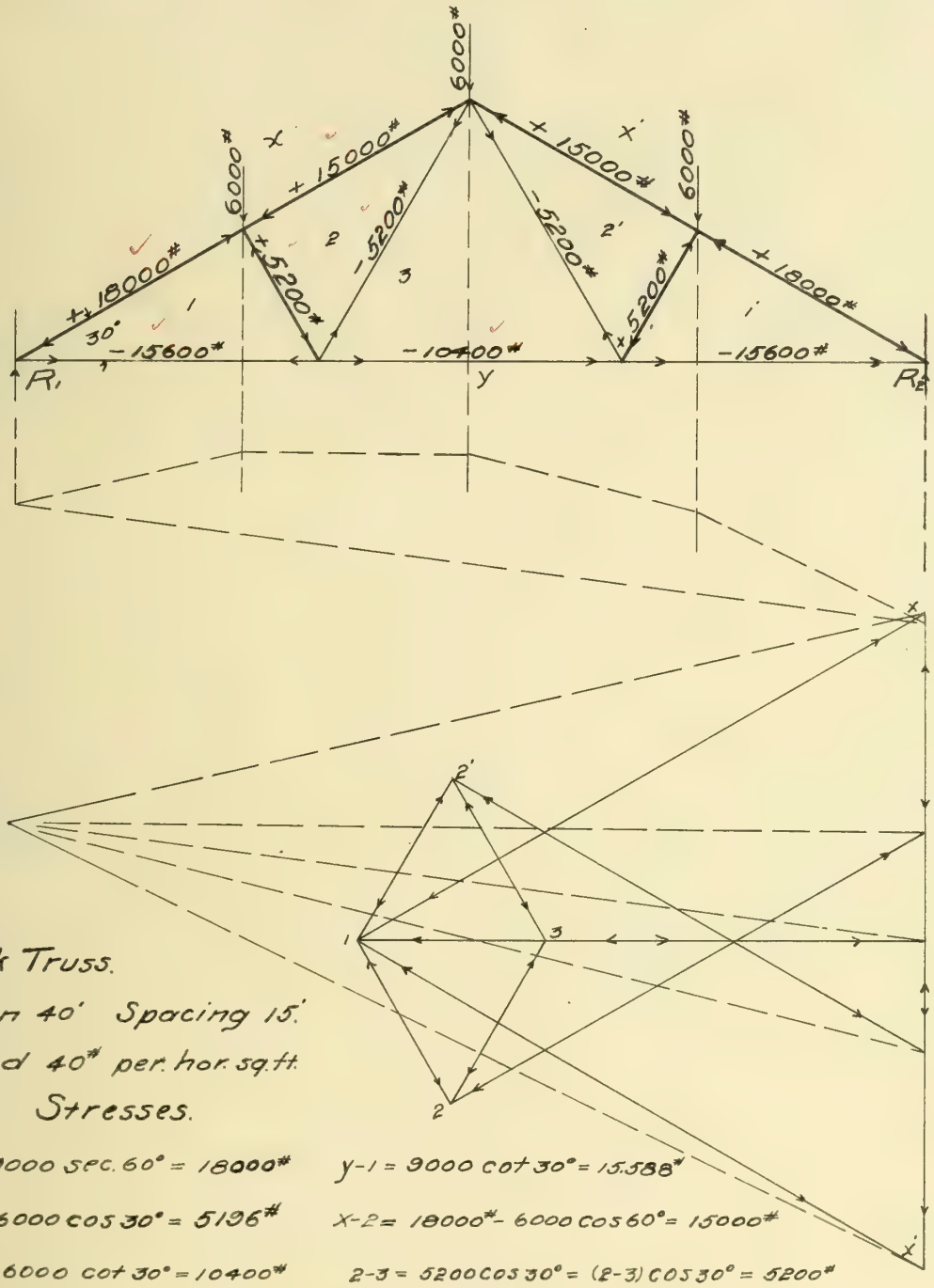
GRAPHIC STATICS.

Prob. No. 7



Fink Truss.

Span 40' Spacing 15'.

Load 40# per. hor. sq. ft.

Stresses.

x-1 = 9000 sec. 60° = 18000# y-1 = 9000 cot 30° = 15588#

1-2 = 6000 cos 30° = 5196# x-2 = 18000# - 6000 cos 60° = 15000#

y-3 = 6000 cot 30° = 10400# 2-3 = 5200 cos 30° = (2-3) cos 30° = 5200#

Scaled Stresses.

x-1 = 18000# y-1 = 15600#

1-2 = 5200# x-2 = 15000#

y-3 = 10400# 2-3 = 5200#

Scale.—

1" = 8' 1" = 5000#

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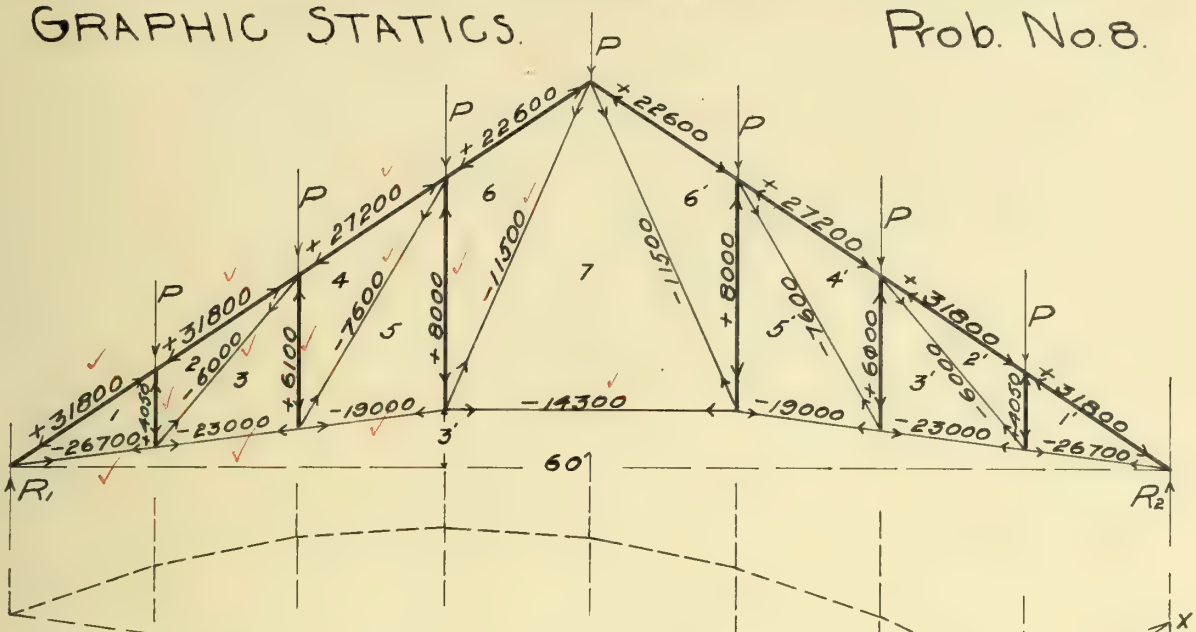
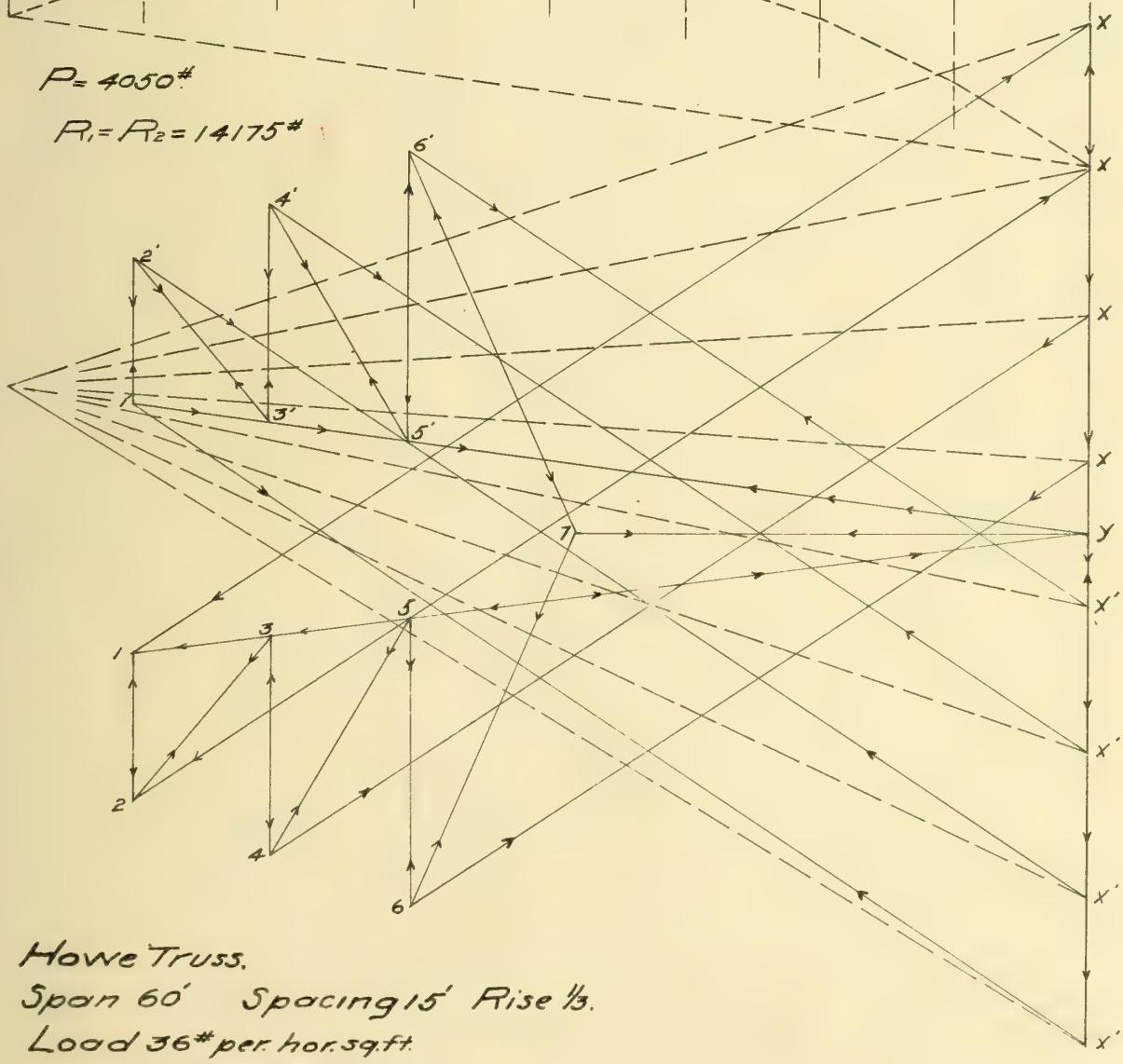
GRAPHIC STATICS. Prob. No. 8.



$P = 4050\#$

$R_1 = R_2 = 14175\#$



Howe Truss.

Span 60' Spacing 15' Rise 1/3.

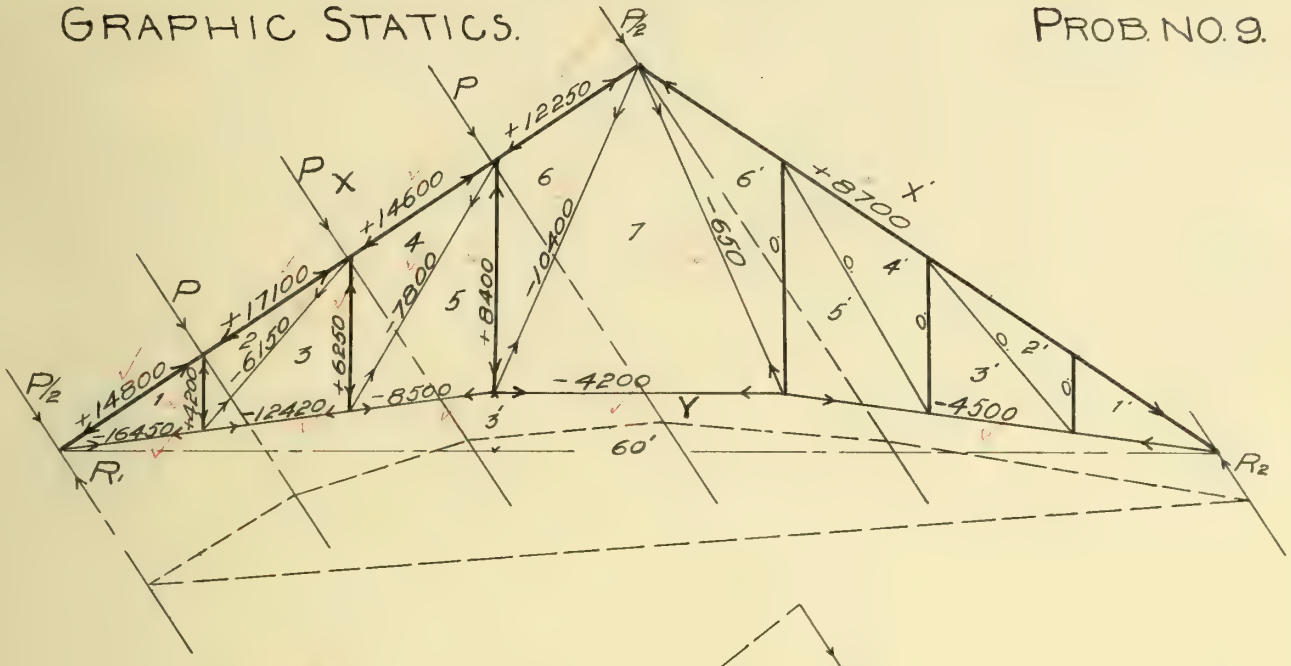
Load 36# per hor. sq. ft.

Scale.— Stress 1" = 10'
Loads 1" = 5000#

F. I. Blair.

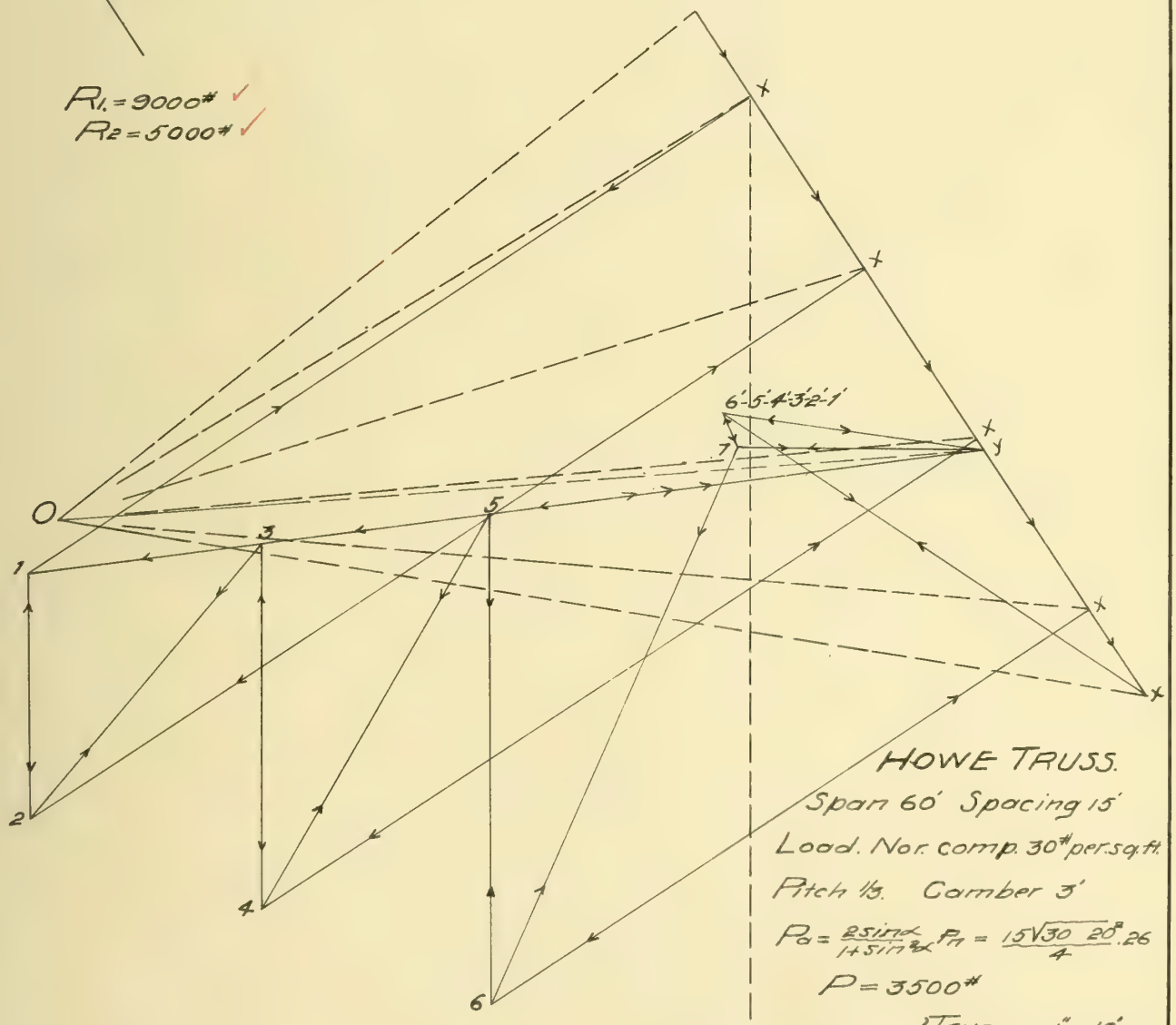
GRAPHIC STATICS.

PROB. NO. 9.



$R_1 = 9000\#$ ✓

$R_2 = 5000\#$ ✓



HOWE TRUSS.

Span 60' Spacing 15'

Load. Nor. comp. 30# per sq. ft.

Pitch 1/3. Camber 3'

$P_a = \frac{2 \sin\alpha}{1 + \sin^2\alpha} P_n = \frac{15\sqrt{30}}{4} \frac{20^2}{.26}$

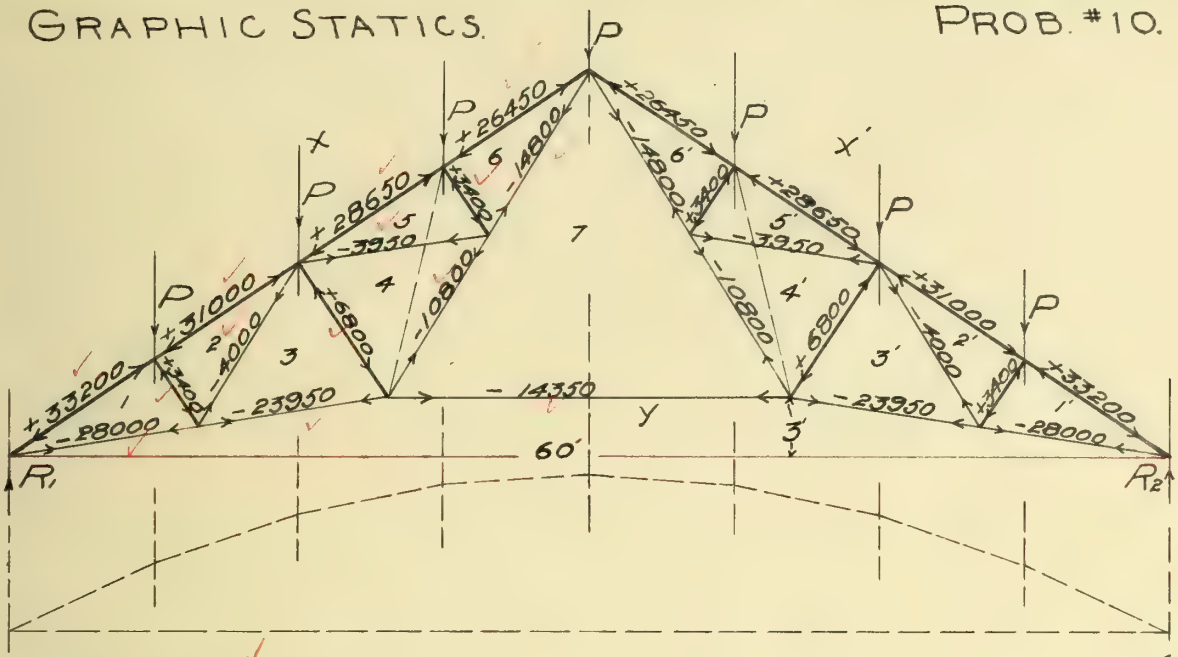
$P = 3500\#$

Scale.– {Trusses 1" = 10'
{Loads 1" = 3000#

F. I. BLAIR.

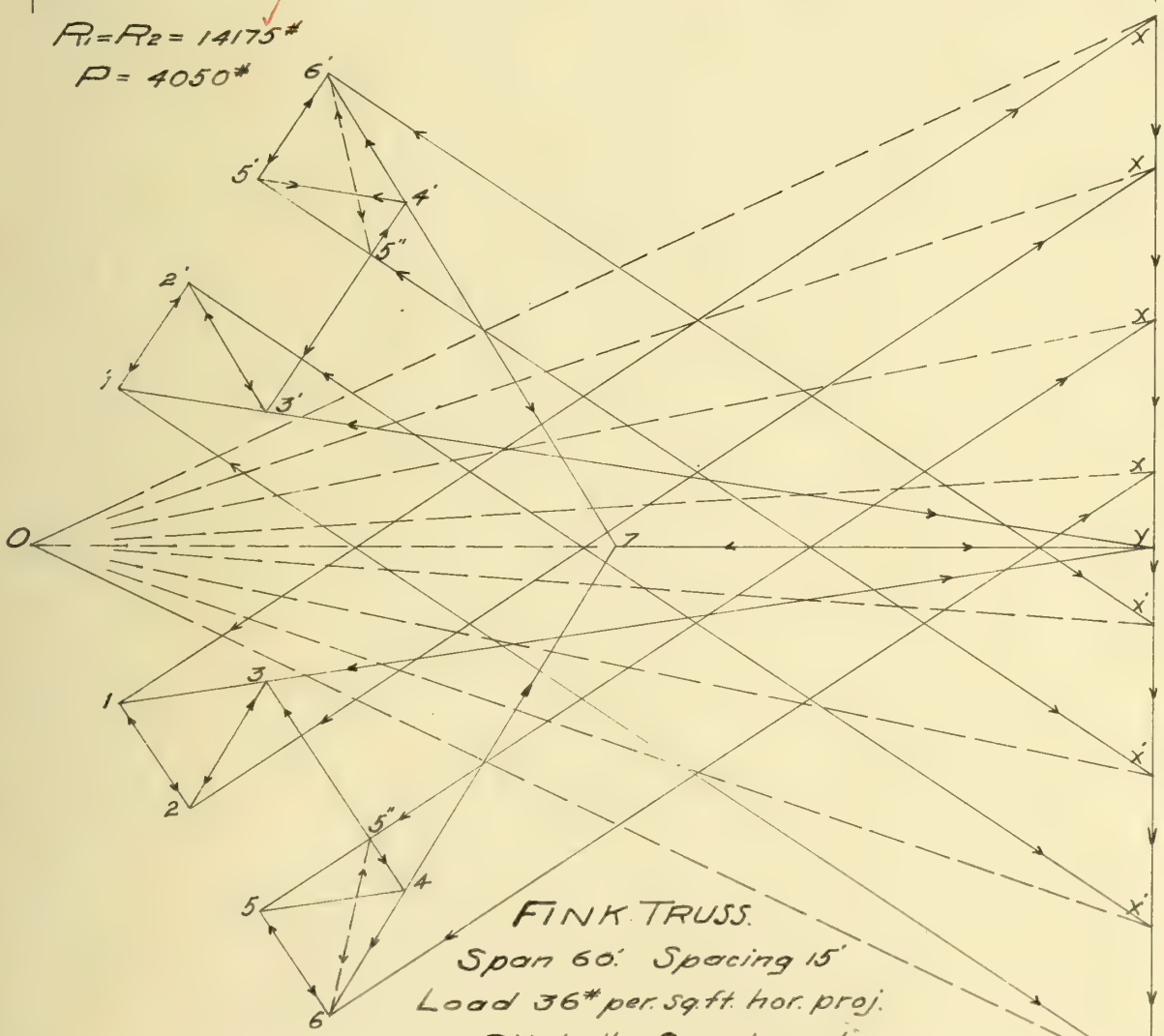
GRAPHIC STATICS.

PROB. #10.



$R_1 = R_2 = 14175\#$

$P = 4050\#$



FINK TRUSS.

Span 60'. Spacing 15'

Load 36# per sq. ft. hor. proj.

Pitch 1/3 Camber 3"

Scale { 1" = 5000#
1" = 10'

Dead Load.

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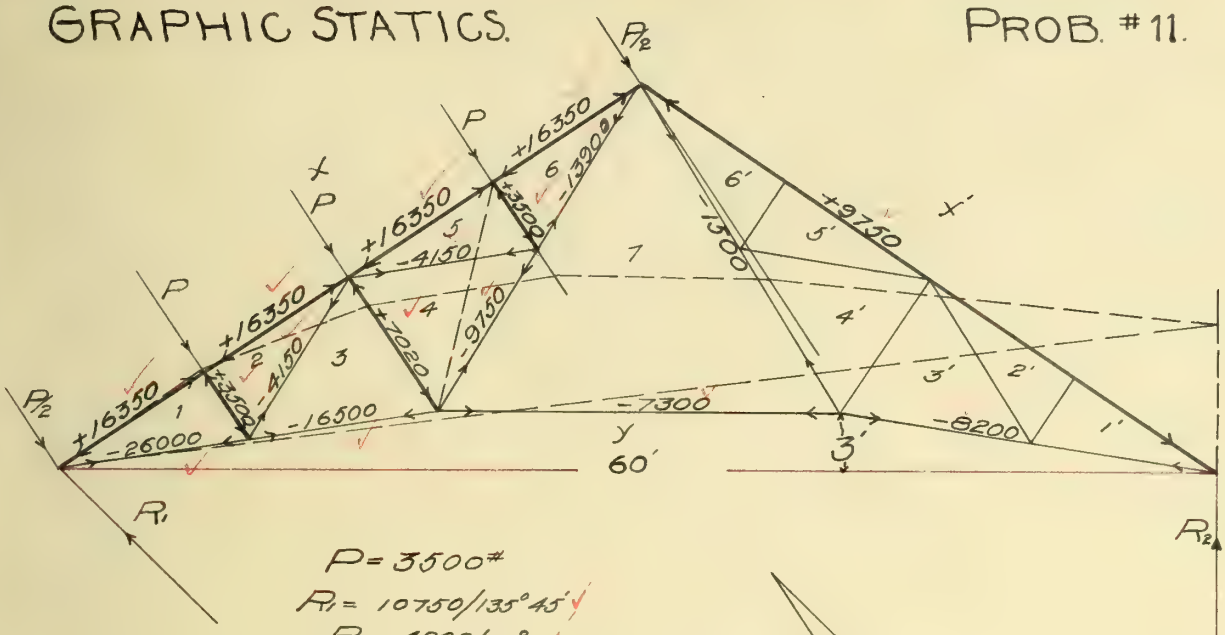
GRAPHIC STATICS.

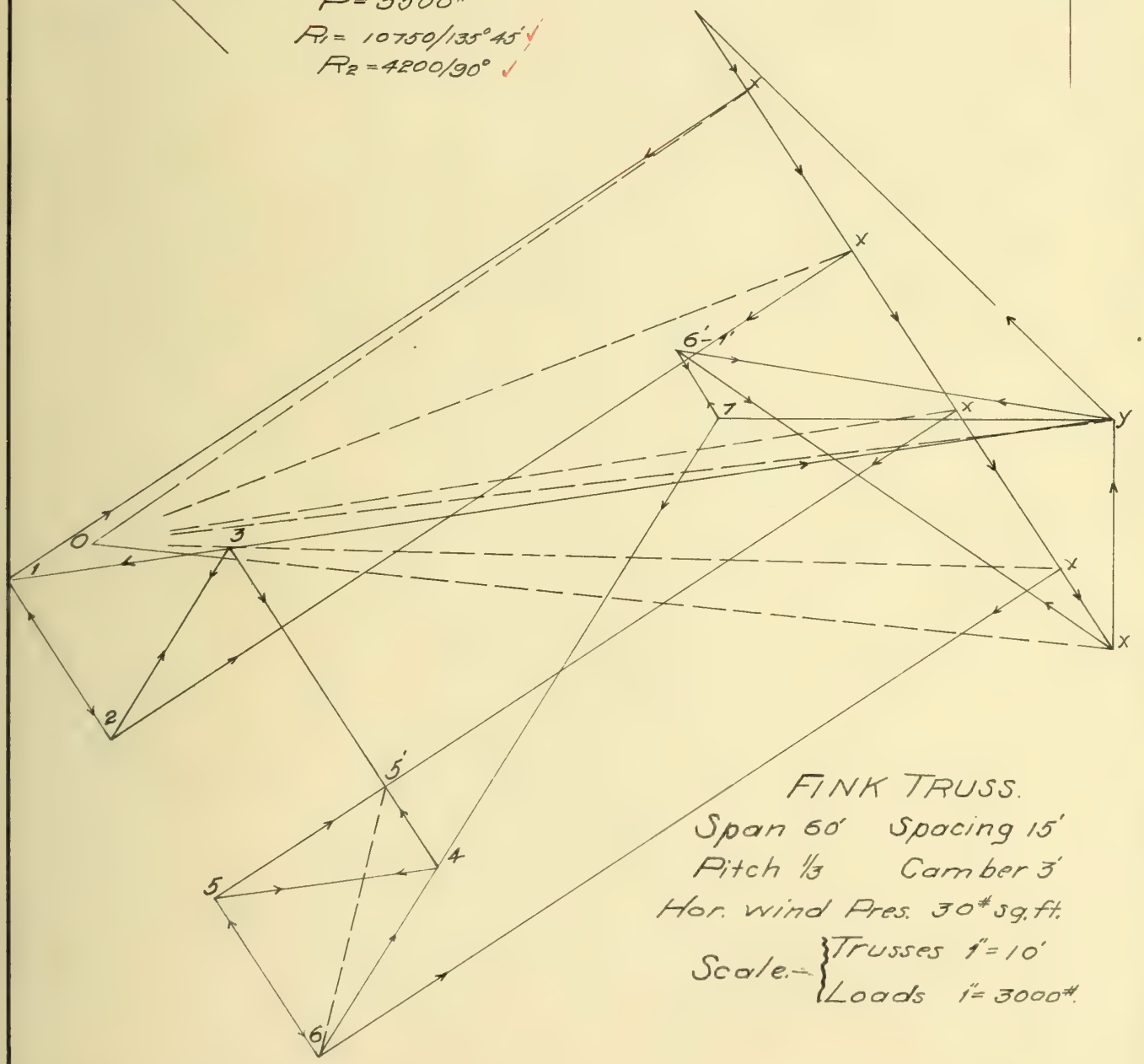
PROB. #11.



$P = 3500^{\#}$

$R_1 = 10750/135°45'$ ✓

$R_2 = 4200/90°$ ✓



FINK TRUSS.

Span 60' Spacing 15'

Pitch 1/3 Camber 3'

Hor. wind Pres. 30# sq. ft.

Scale.— Trusses 1" = 10'

Loads 1" = 3000#.

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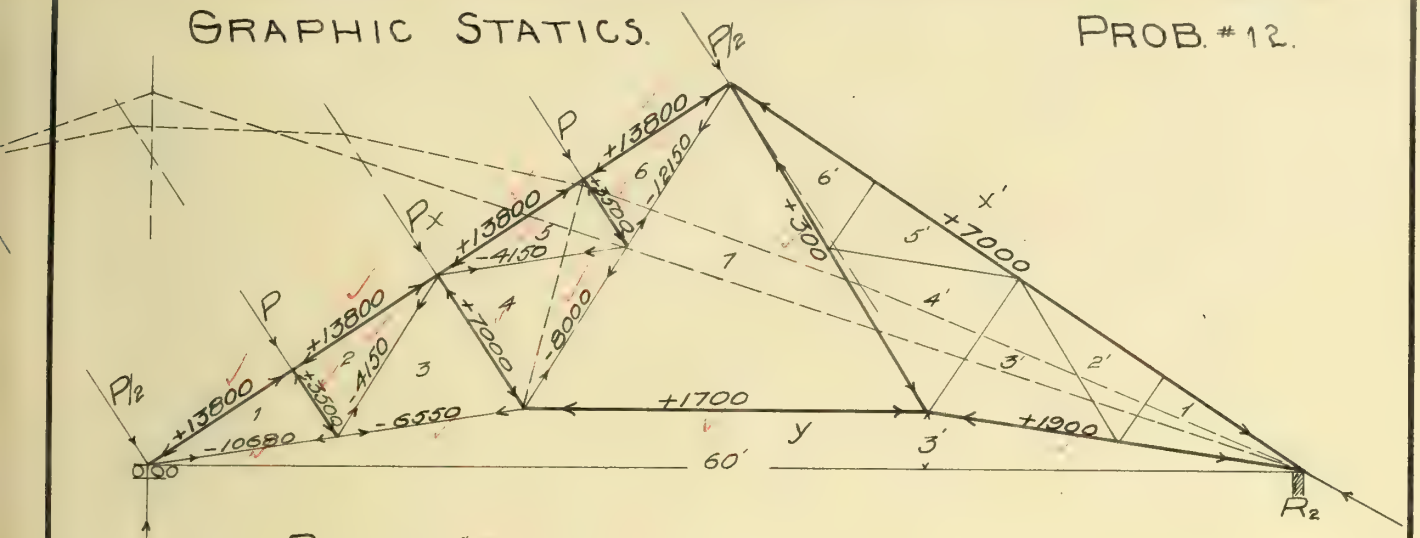
GRAPHIC STATICS.

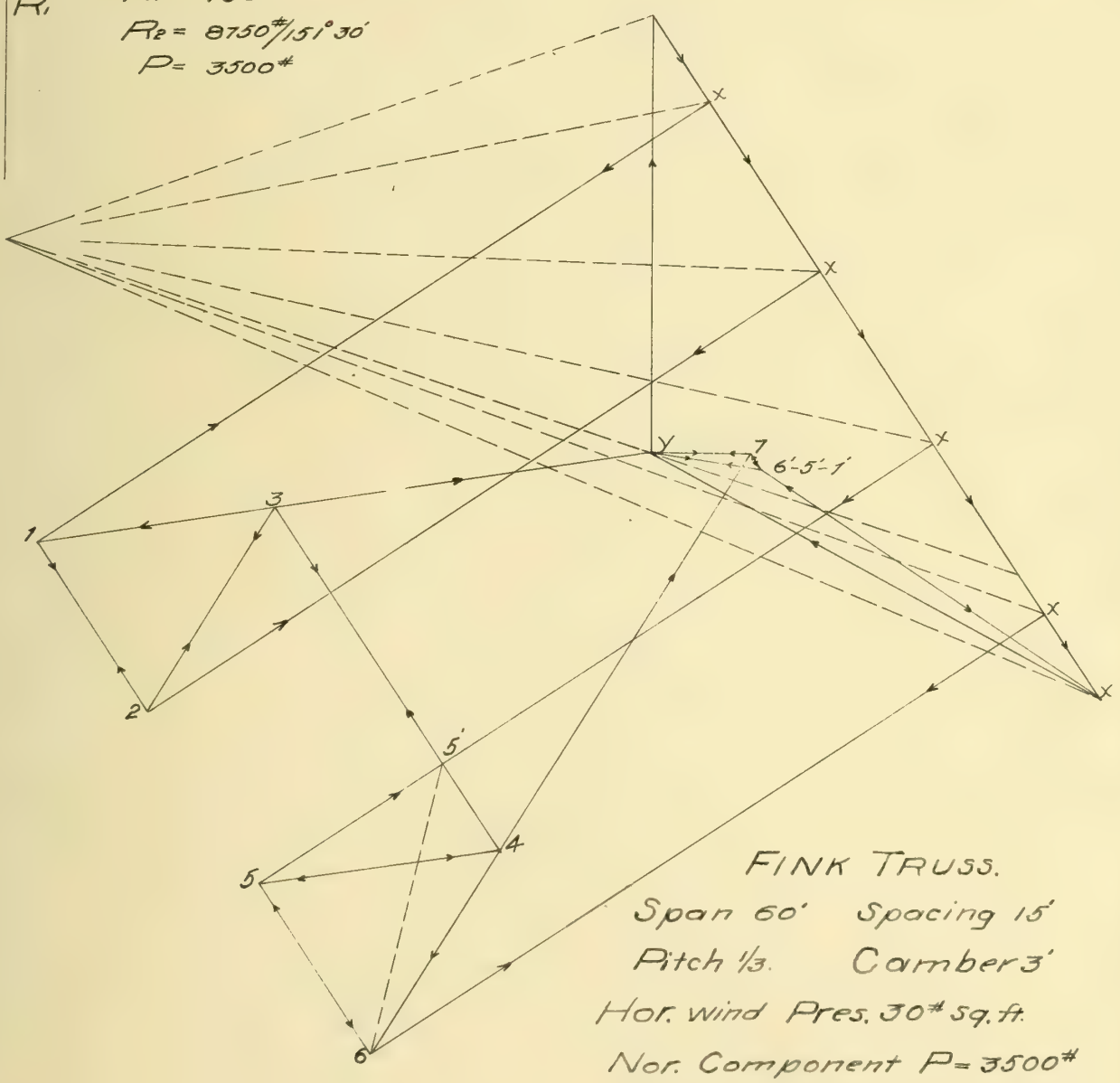
PROB. # 12.



$R_1 = 7500^{\#}$

$R_2 = 8750^{\#} / 51° 30'$

$P = 3500^{\#}$



FINK TRUSS.

Span 60' Spacing 15'

Pitch 1/3. Camber 3'

Hor. wind Pres. 30# sq. ft.

Nor. Component P = 3500#

Scale.— Trusses 1" = 10'

Load 1" = 3000#

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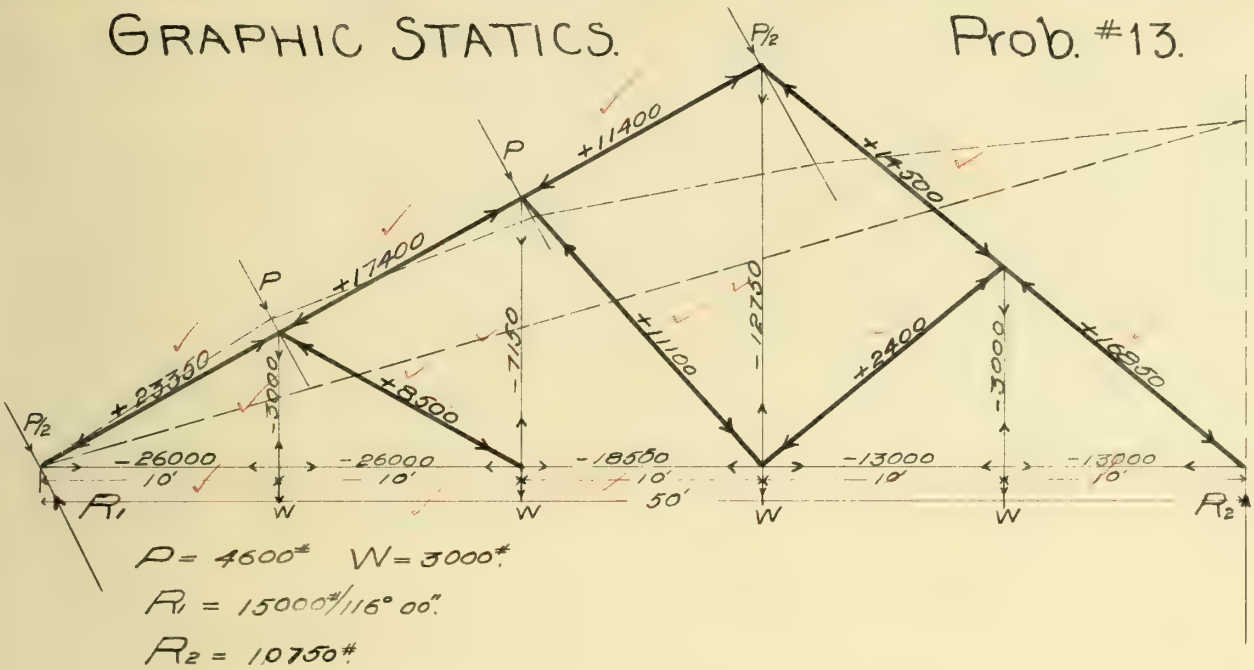
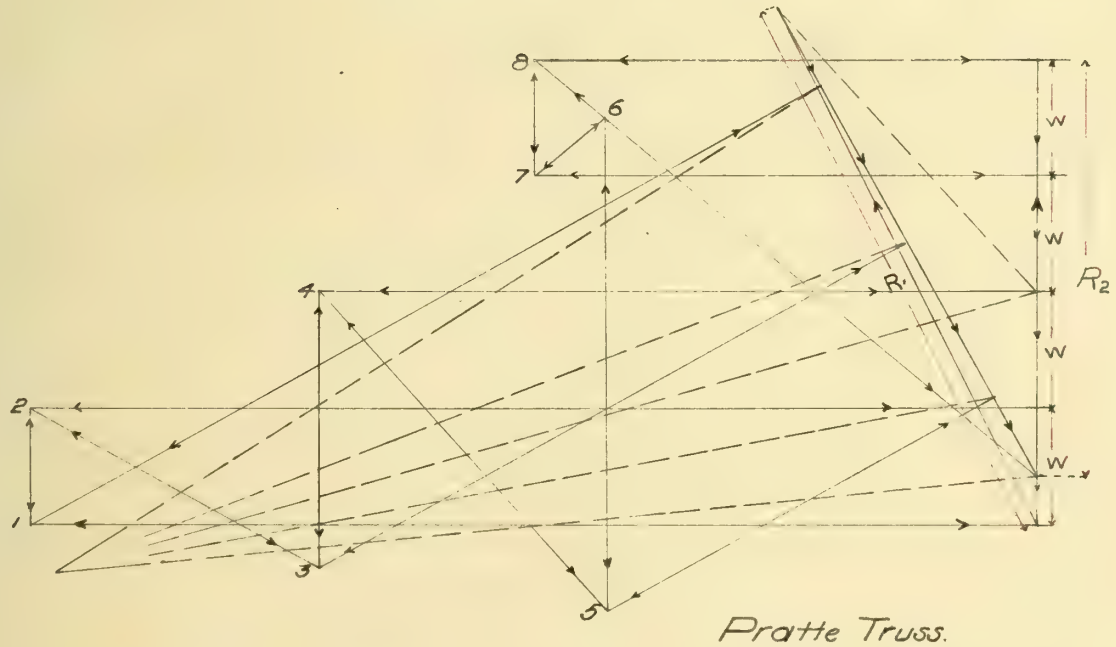
GRAPHIC STATICS. Prob. #13.



P = 4600# W = 3000#.

R1 = 15000#/116° 00".

R2 = 10750#.



Pratte Truss.

Span 50' Pitch 1/3.

Scale.- {Loads 1"=5000#
{Truss 1"=8'

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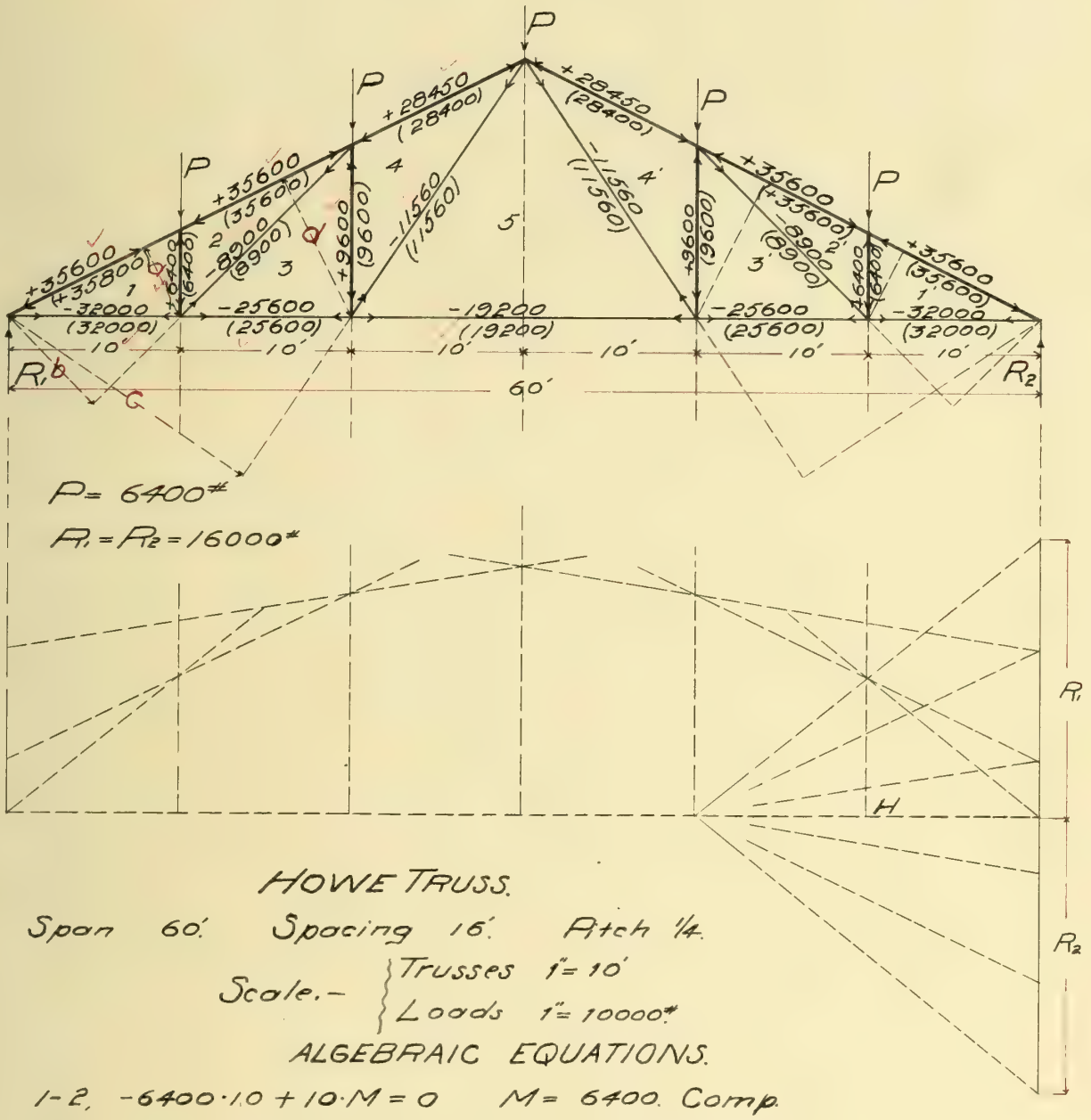
GRAPHIC STATICS. Problem. 14.



P = 6400#

$R_1 = R_2 = 16000$#

HOWE TRUSS.

Span 60'. Spacing 16'. Pitch 1/4.

Scale.— Trusses 1" = 10'
Loads 1" = 10000#

ALGEBRAIC EQUATIONS.

1-2, $-6400 \cdot 10 + 10 \cdot M = 0$ $M = 6400$. Comp.

x-1, $-16000 \cdot 10 + a \cdot M = 0$ $M = 35800$. Comp.

y-1, $-16000 \cdot 10 + 5(-M) = 0$ $M = 32000$. Tens.

2-3, $-6400 \cdot 10 + b(-M) = 0$ $M = 8900$. Tens.

x-2, $-16000 \cdot 10 + a \cdot M = 0$ $M = 35600$. Comp.

y-3, $-16000 \cdot 20 + 6400 \cdot 10 - 10(M) = 0$. $M = 25600$. Tens.

3-4, $-6400 \cdot 10 - 6400 \cdot 20 + 20M = 0$ $M = 9600$ Comp.

4-5, $-6400 \cdot 10 - 6400 \cdot 20 - c(-M) = 0$ $M = 11560$. Tens.

x-4, $-16000 \cdot 20 + 6400 \cdot 10 + d \cdot M = 0$ $M = 28400$. Comp.

y-5, $-16000 \cdot 30 + 64000 \cdot 2 + 6400 \cdot 10 - 15(M) = 0$ $M = 19200$ Tens.

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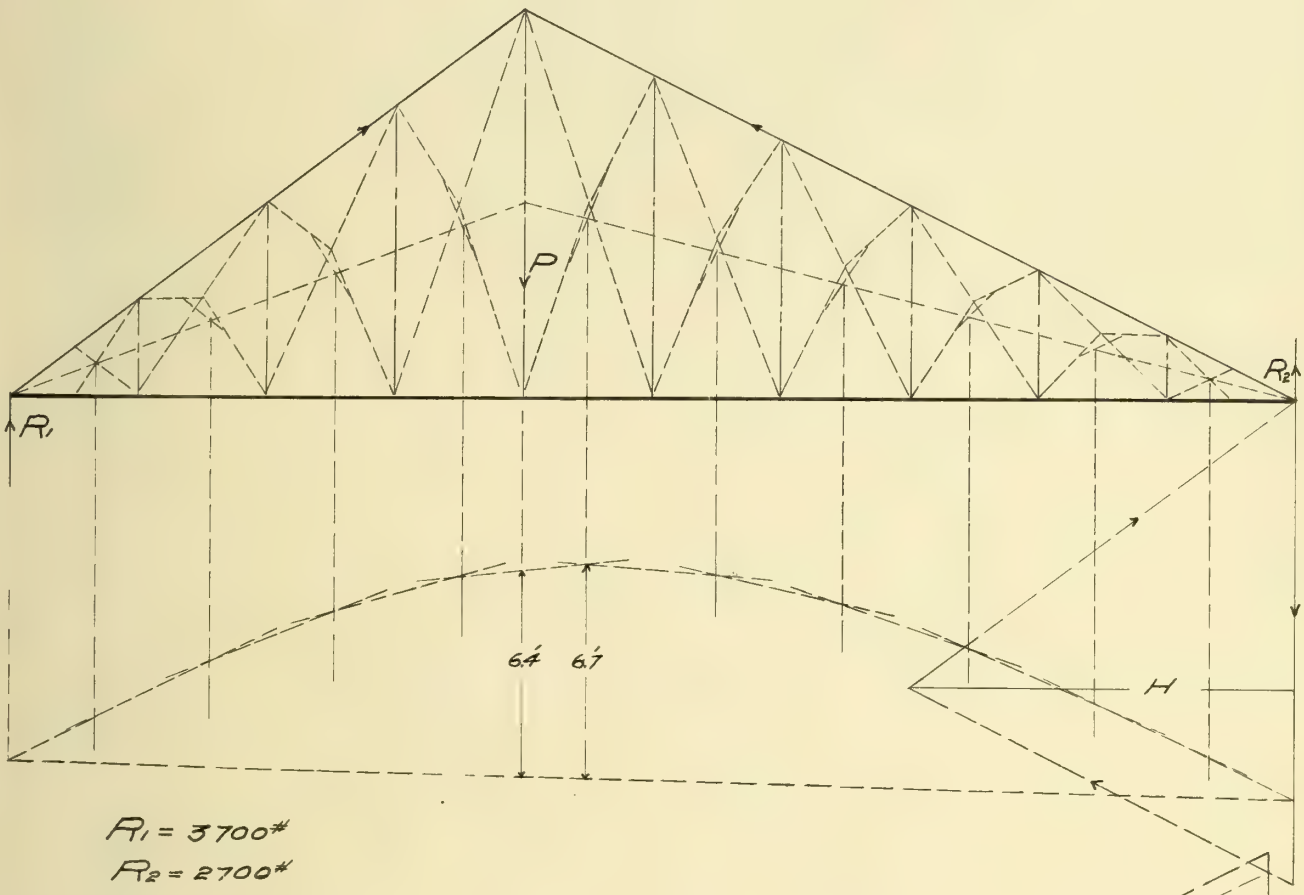
GRAPHIC STATICS.

Problem #15.



$R_1 = 3700\#$

$R_2 = 2700\#$

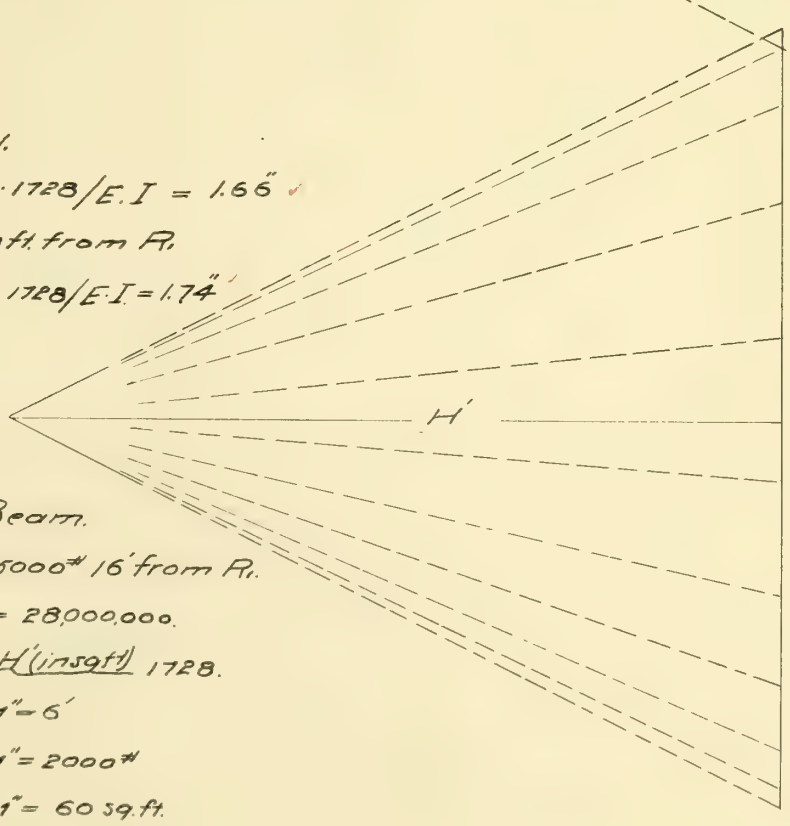
$P = 5000\#$

Deflection under load.

$\Delta'' = 6.4 \cdot 4000 \cdot 240 \cdot 1728 / E.I = 1.66''$

Max. Deflection at 18ft. from R_1

$\Delta'' = 6.7 \cdot 4000 \cdot 240 \cdot 1728 / E.I = 1.74''$



Given.– 12"–35# Eye Beam.

Span 40' Load 5000# 16' from R_1.

$I = 228.3$ $E = 28{,}000{,}000.$

$$\Delta'' = \frac{y(\text{in ft}) \cdot H(\text{in lbs}) \cdot H'(\text{in sq ft})}{E.I} 1728.$$

Scale.– Beam 1"=6'
Loads 1"=2000#
Areas 1"= 6039 ft.

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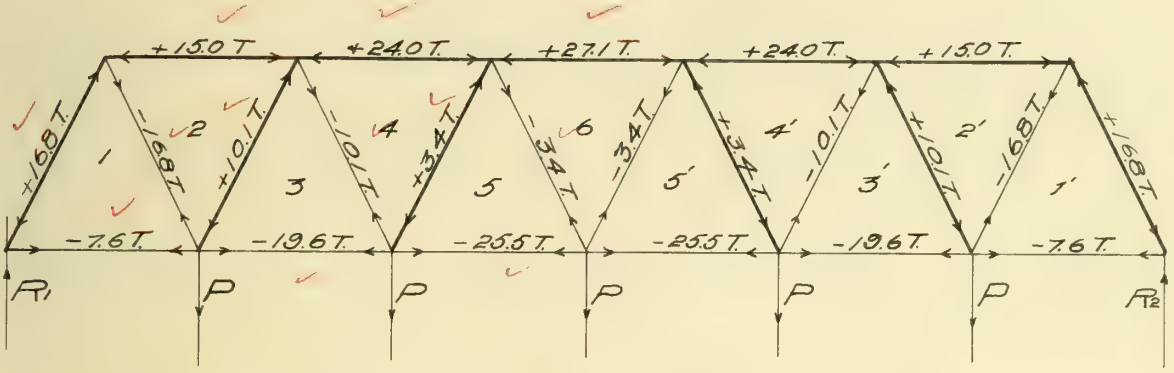
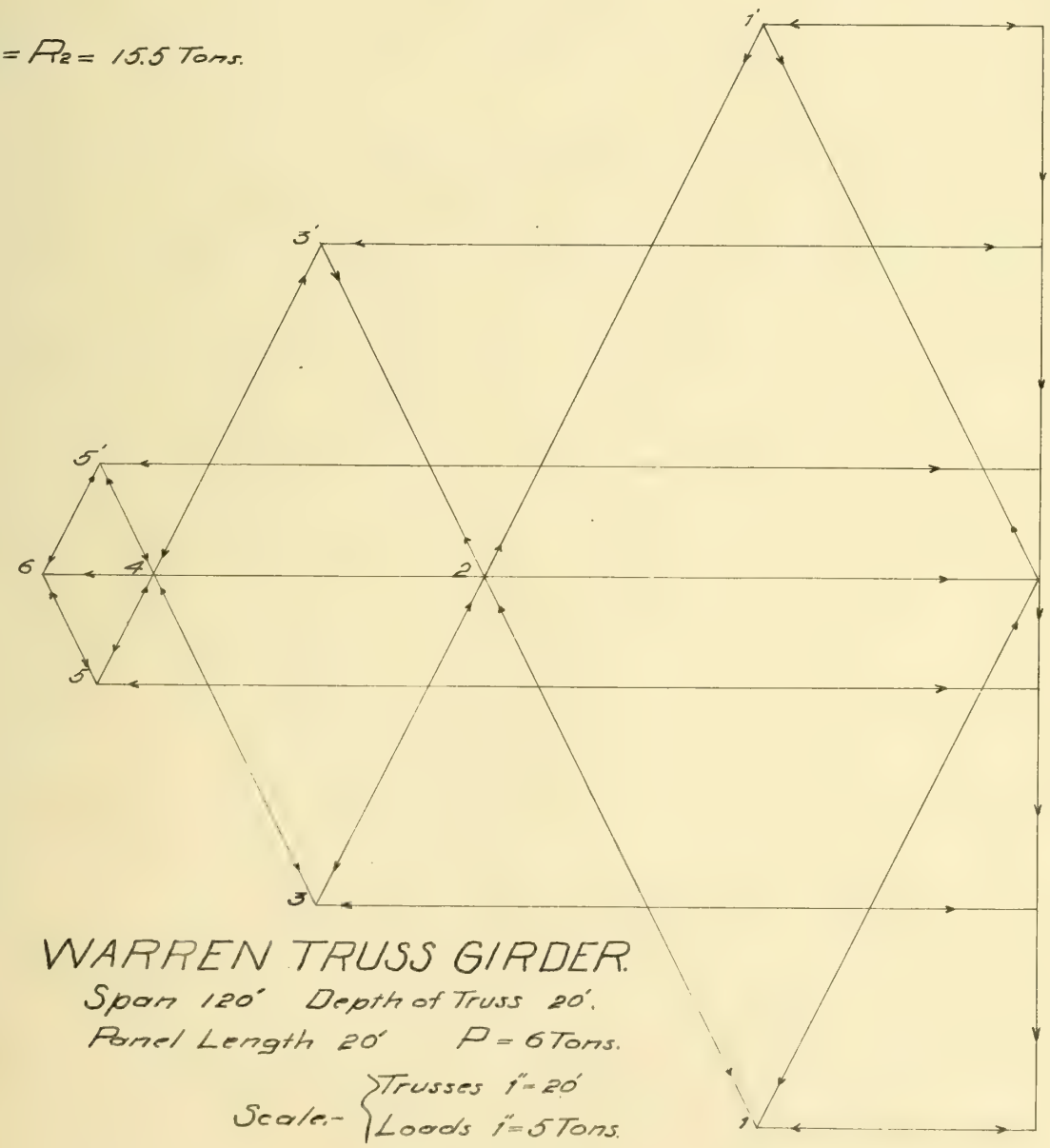
GRAPHIC STATICS.

Problem # 16.



$R_1 = R_2 = 15.5$ Tons.



WARREN TRUSS GIRDER.

Span 120' Depth of Truss 20'.

Panel Length 20' P = 6 Tons.

Scale.- Trusses 1" = 20'
Loads 1" = 5 Tons.

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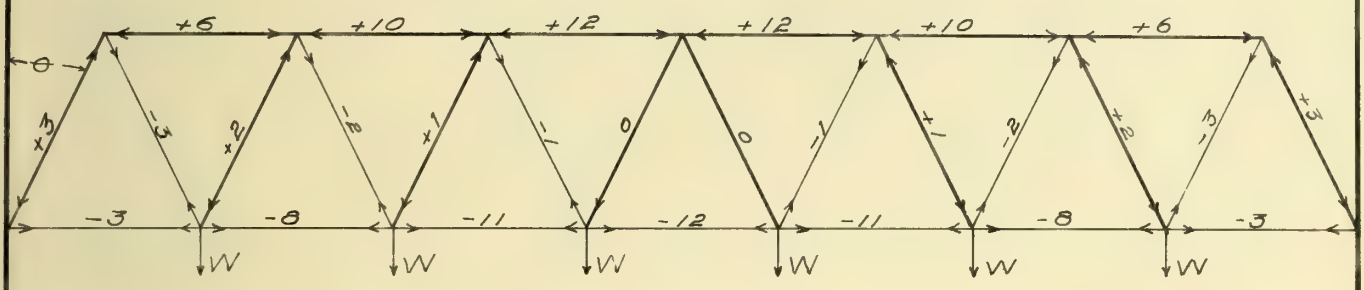
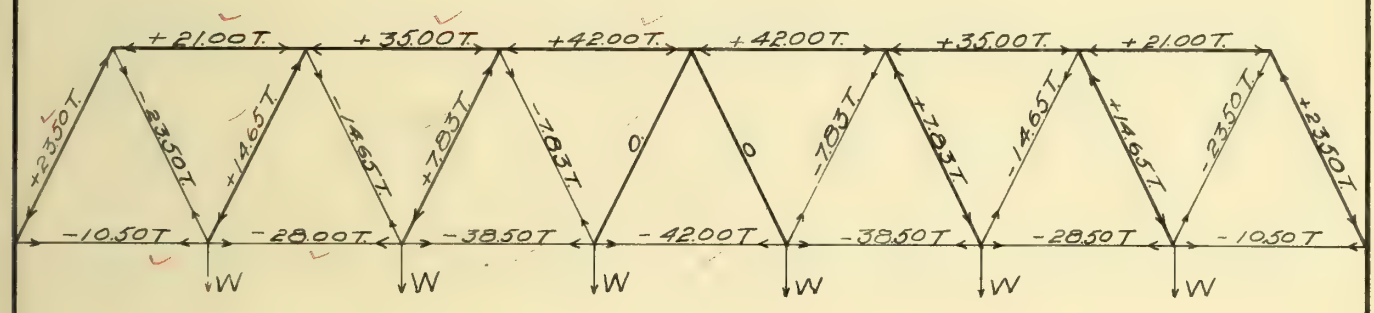
GRAPHIC STATICS. Problem #17.





WARREN TRUSS GIRDER

Span 140'. l = 20' d = 20'.

W = 7 Tons. N = 7.

θ = 26°34' { tang. θ = 0.500. Sec. θ = 1.118.

Scale of Trusses. — 1" = 20'

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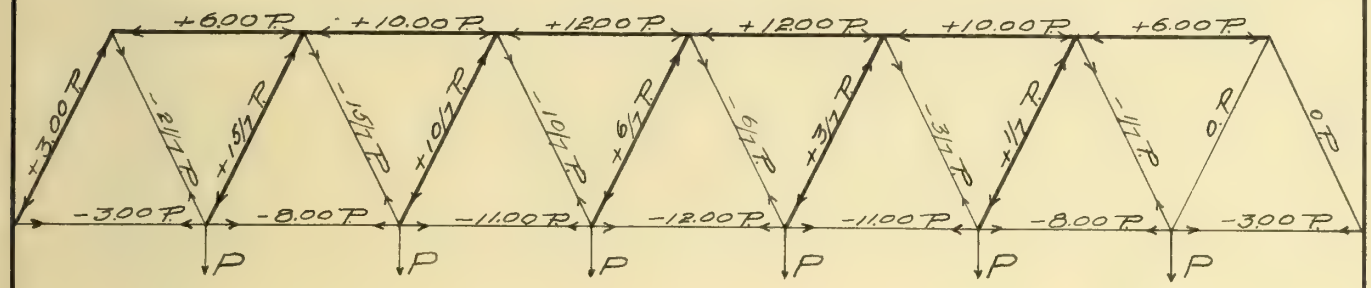
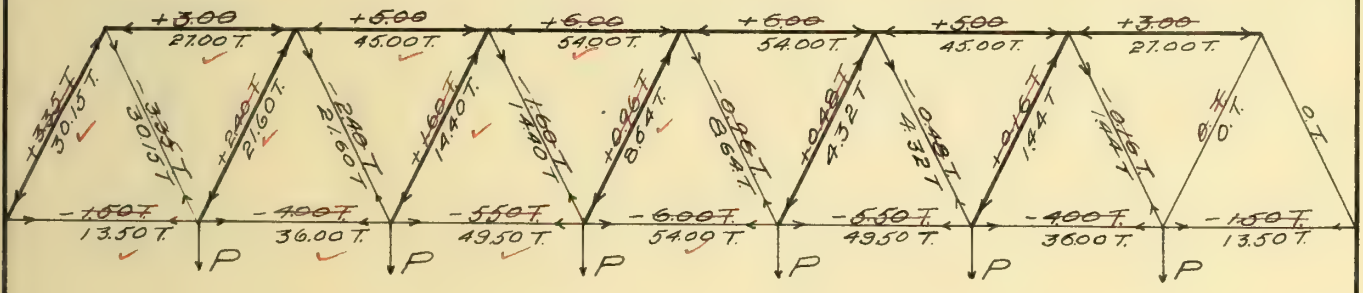
GRAPHIC STATICS.

Problem # 18.





WARREN TRUSS GIRDER.

Span = 140′ l = 20′ d = 20′

P = 9 Tons. θ = 26° 34′

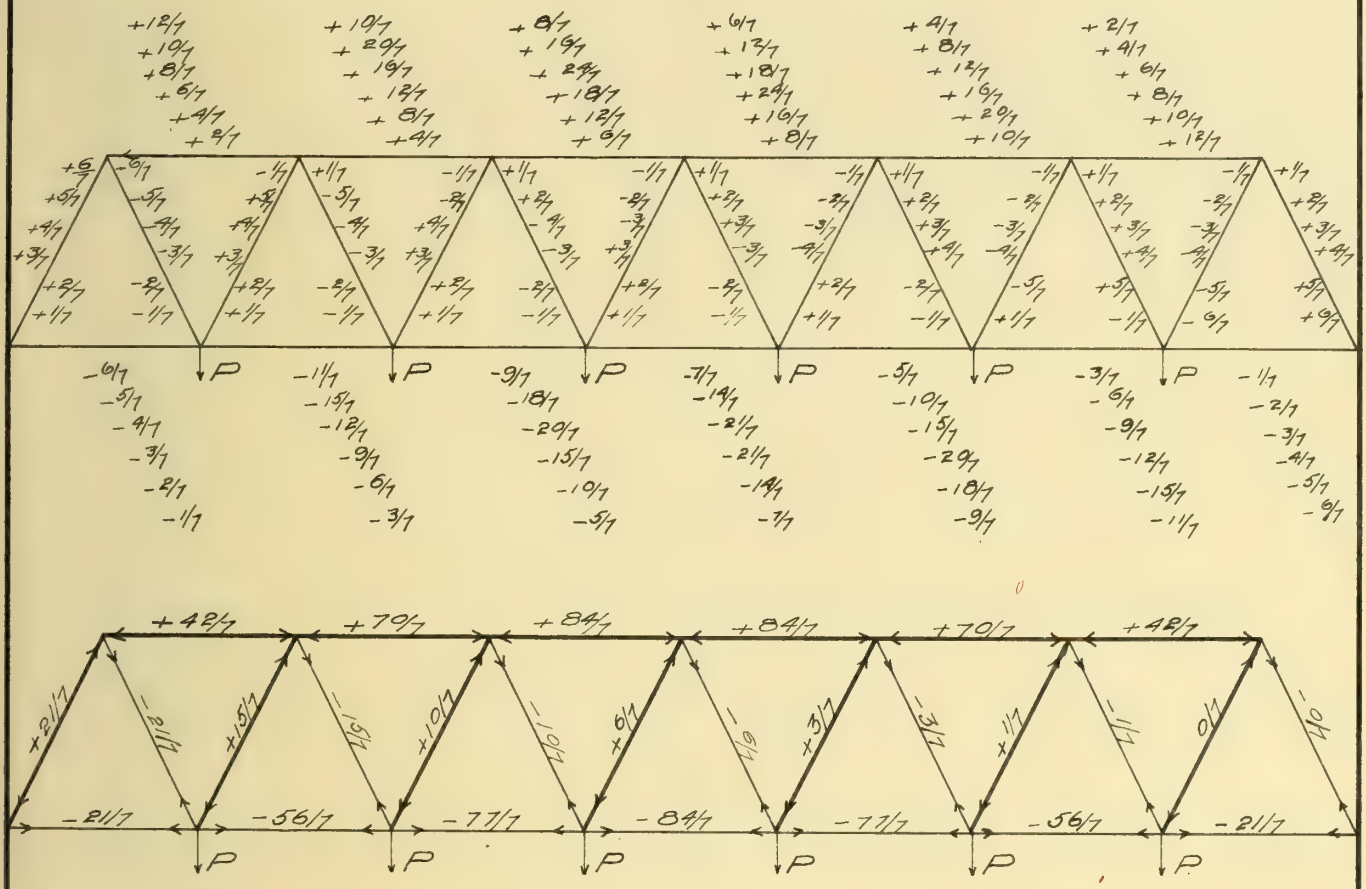
tan θ = 0.500 sec θ = 1.118.

Scale of trusses. - 1" = 20′

F. S. Blair

GRAPHIC STATICS

Problem # 19



WARREN TRUSS GIRDER.

Span 140' d- 20' l 20' N 7.

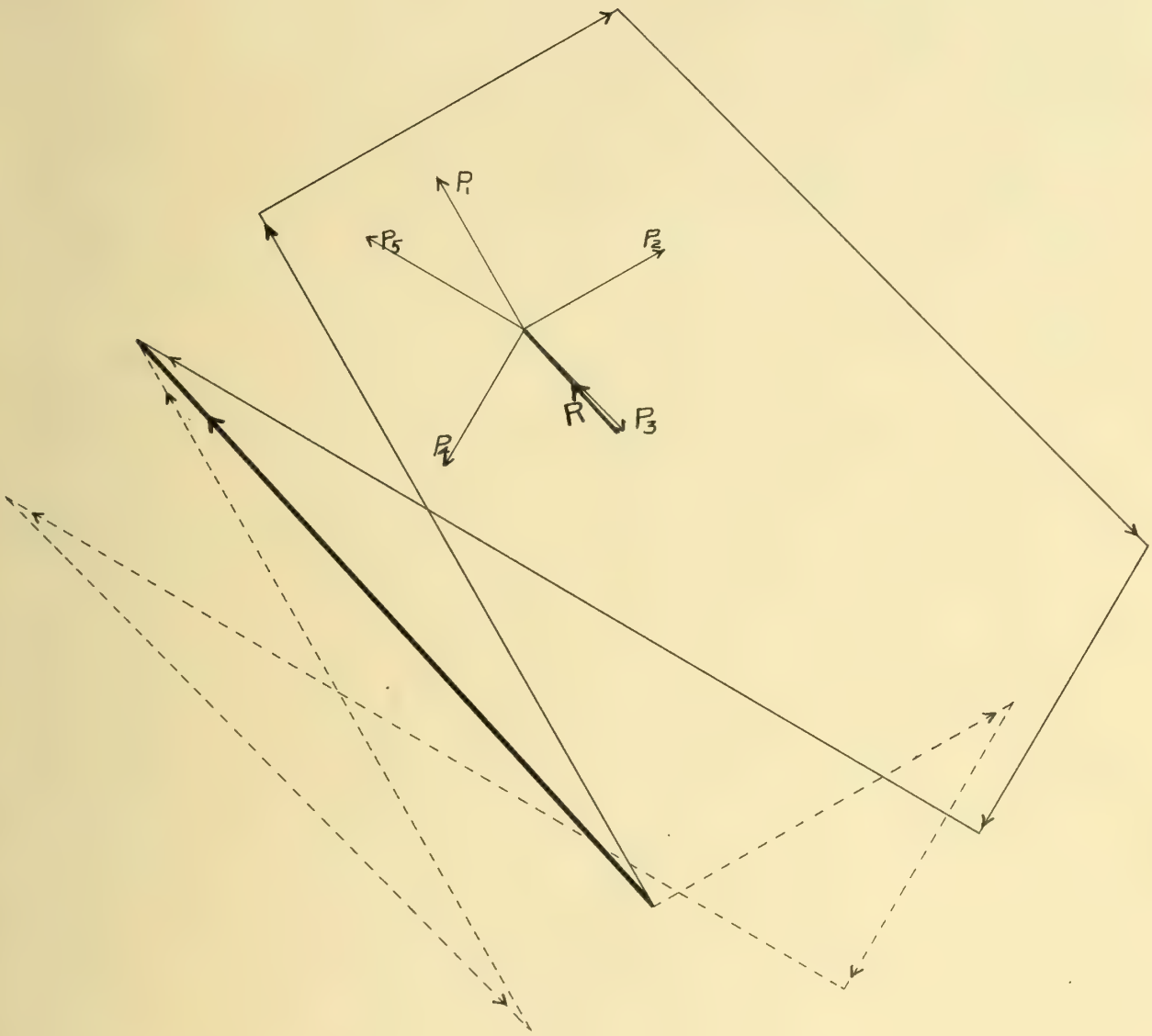
Coefficients as load moves to the right.

Scale- 1" = 20'

F. I. Blair

GRAPHIC STATICS.

Prob. 1.



$\Sigma P\cos\theta = 1172.75 = R\cos\theta_1$

$\Sigma P\sin\theta = 1278.83 = R\sin\theta_1$

$1172.75^2 + 1278.83^2 = R^2$

$R = 1735 +$

$\frac{1278.83}{1172.75} = \tan\theta_1$

$\theta_1 = 132° 31'$

Graphic Values $\begin{cases} R = 1735. \\ \theta_1 = 132\frac{1}{2}° \end{cases}$

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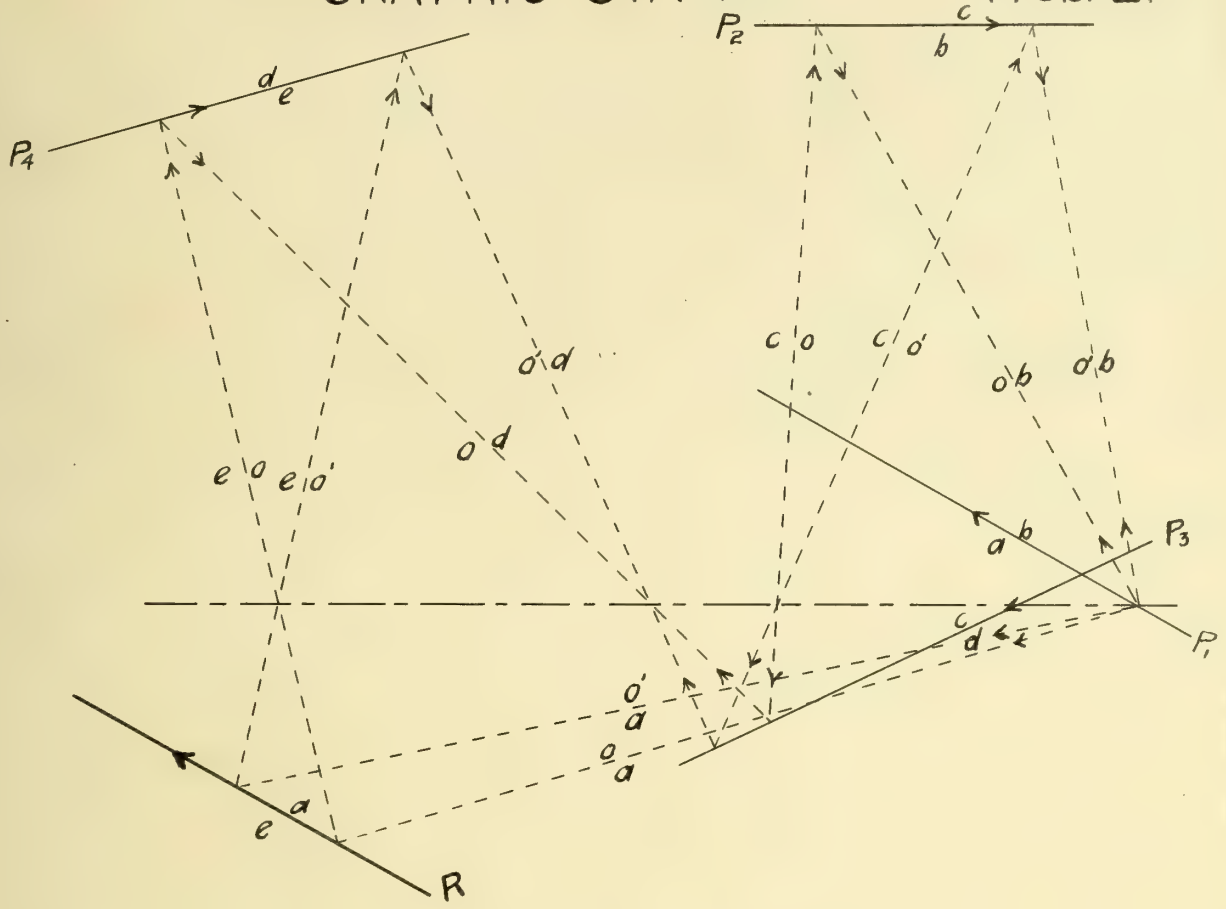
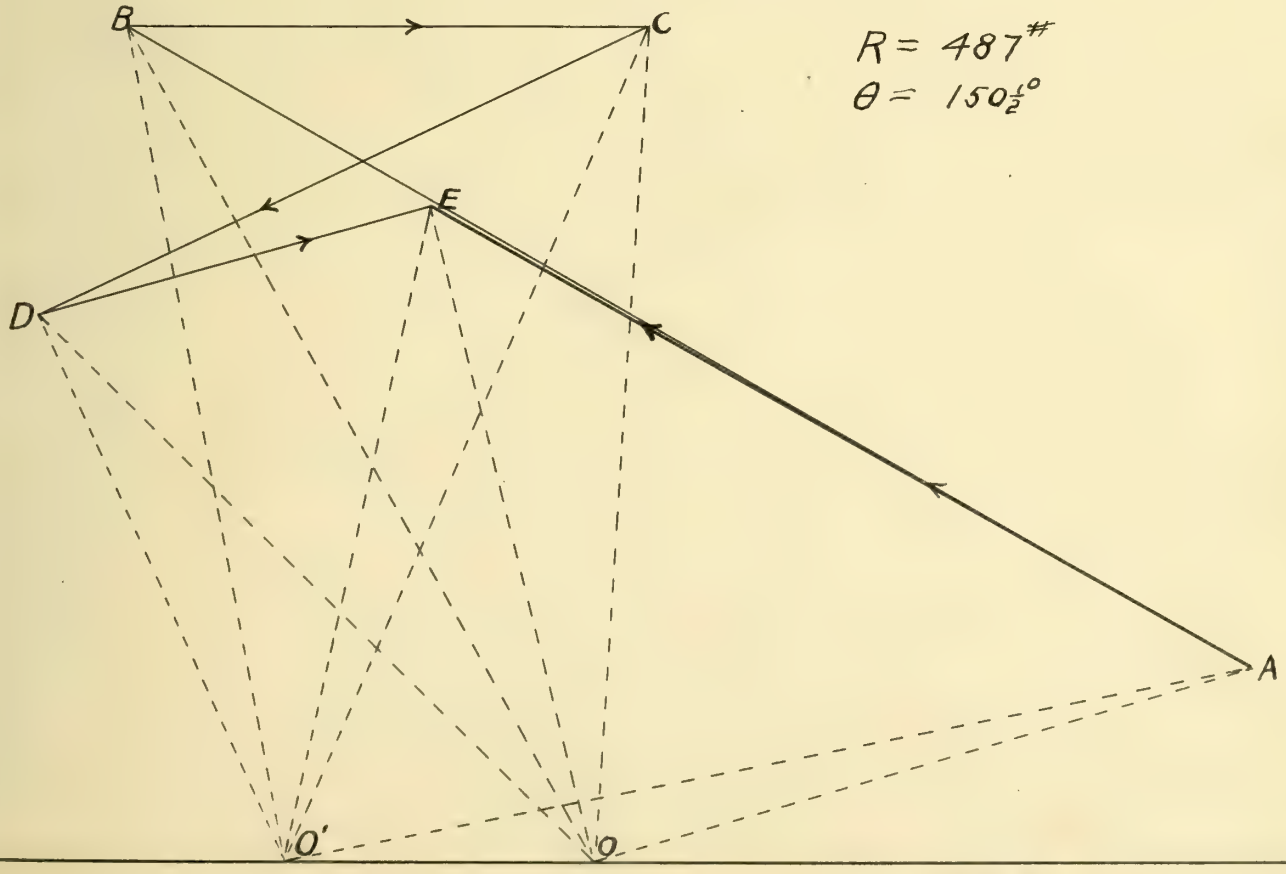
GRAPHIC STATICS. Prob. 2.





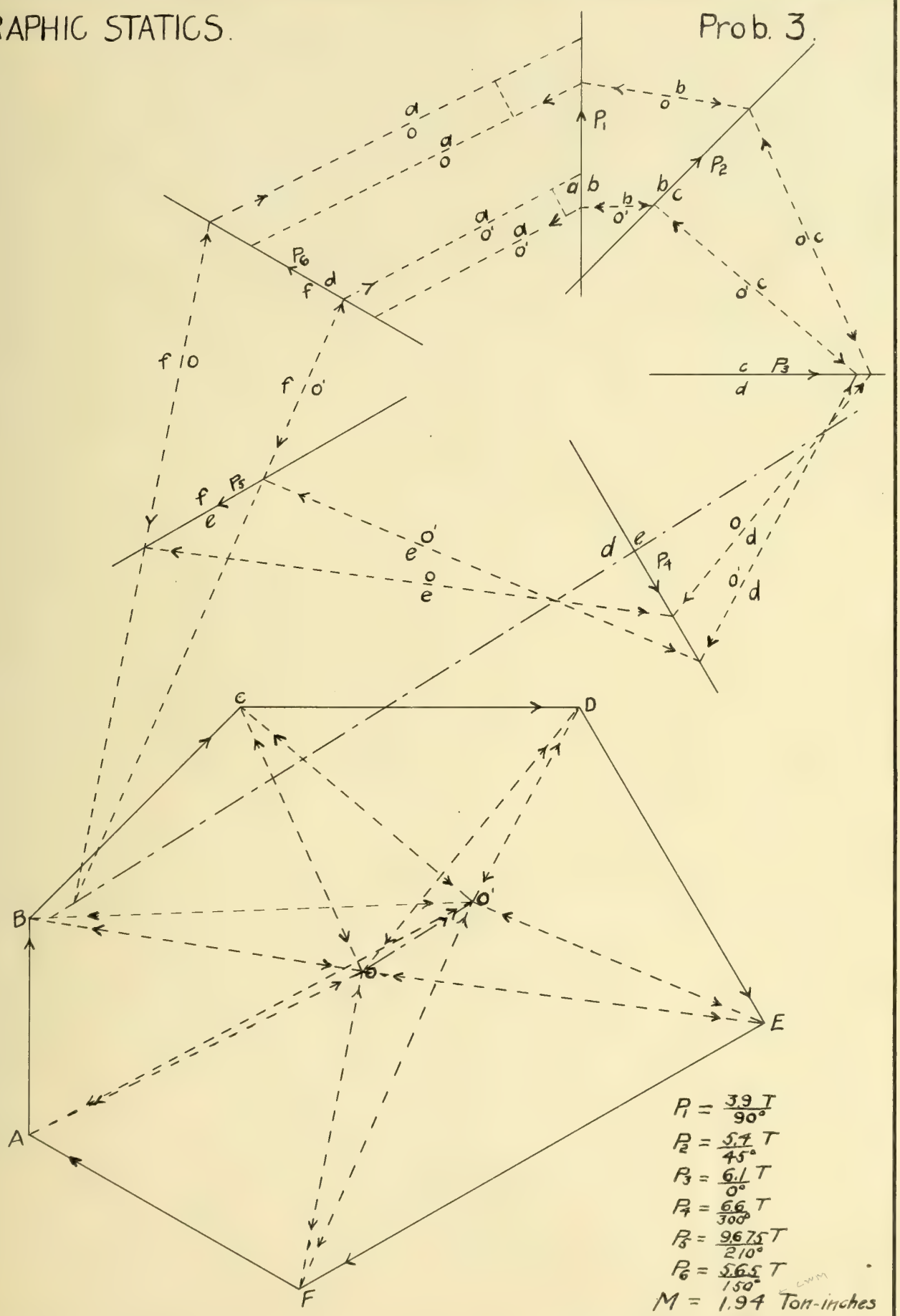
$R = 487^{\#}$

$\theta = 150\frac{1}{2}^{\circ}$

L. E. Cunfman.

GRAPHIC STATICS.

Prob. 3.



$P_1 = \frac{3.9\ T}{90°}$

$P_2 = \frac{5.4\ T}{45°}$

$P_3 = \frac{6.1\ T}{0°}$

$P_4 = \frac{6.6\ T}{300°}$

$P_5 = \frac{9.675\ T}{210°}$

$P_6 = \frac{5.65\ T}{150°}$

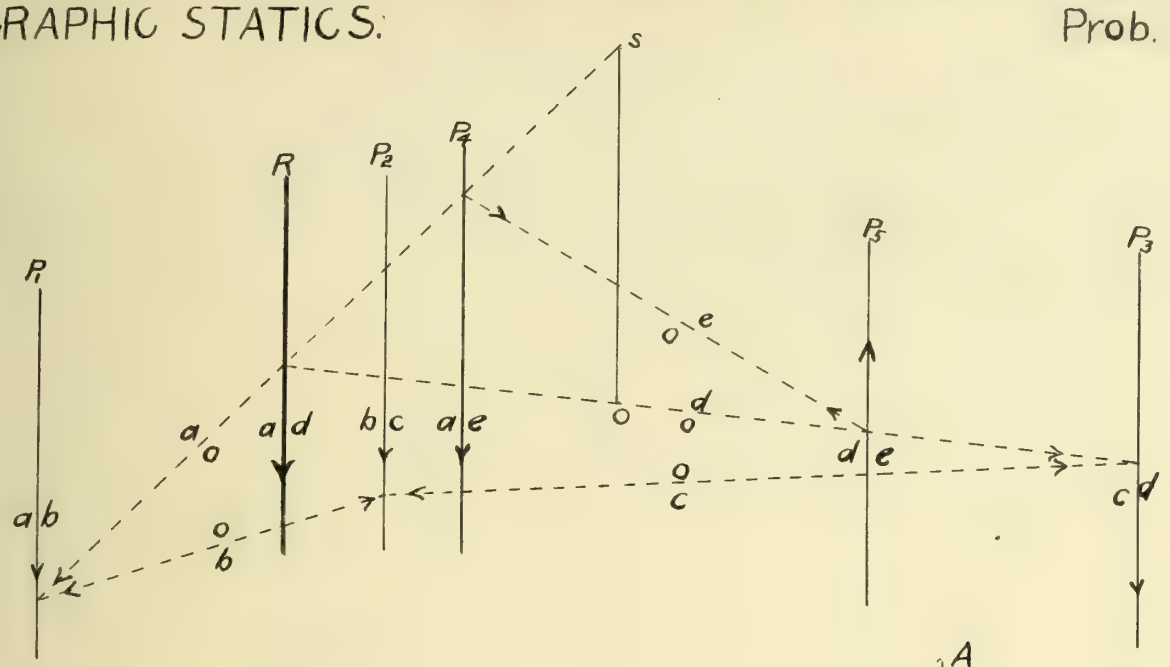
$M = 1.94$ Ton-inches

$M' = 198$ " "

L. E. Curfman

GRAPHIC STATICS.

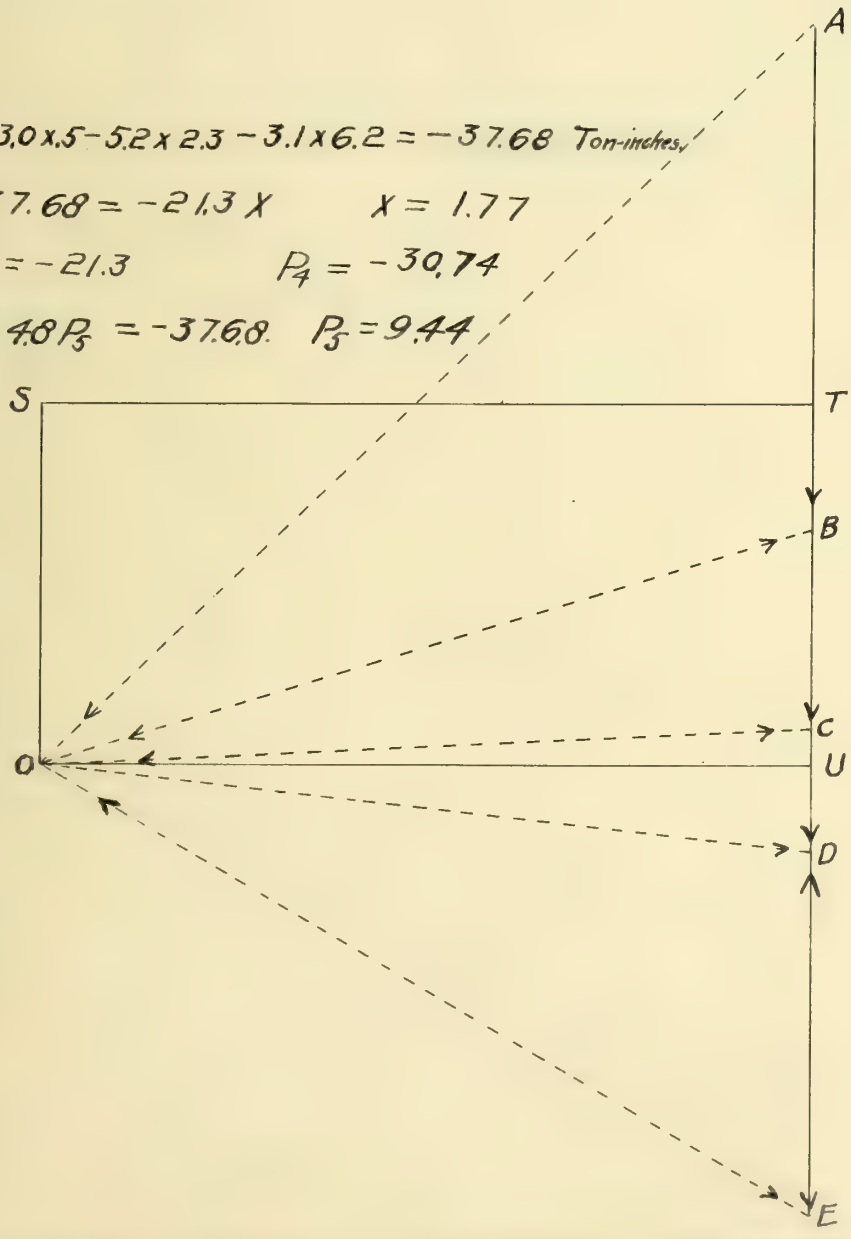
Prob. 4.



$M_{123} = -13.0 \times 5 - 5.2 \times 2.3 - 3.1 \times 6.2 = -37.68$ Ton-inches.

$M_R = -37.68 = -21.3\,X \qquad X = 1.77$

$$\begin{cases} P_4 + P_5 = -21.3 & P_4 = -30.74 \\ 2.7P_4 + 4.8P_5 = -37.68. & P_5 = 9.44 \end{cases}$$



$P_1 = 13.0$ T.

$P_2 = 5.2$

$P_3 = 3.1$

$R = 21.3$

$P_4 = 30.8$

$P_5 = -9.4$

$M_R = OU \times OS$

$= 37.0$ Ton-inches

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GRAPHIC STATICS.

Prob. 5.

$M_y = 1\frac{1}{8} \times \frac{3}{4} + 1\frac{1}{2} \times \frac{3}{8} + 1\frac{11}{16} \times 1\frac{1}{8} + 1\frac{5}{16} \times 2\frac{5}{8} = 6.75$

$M_x = 1\frac{1}{8} \times 3\frac{1}{8} + 1\frac{1}{2} \times 1\frac{3}{4} + 1\frac{11}{16} \times \frac{3}{8} + 1\frac{5}{16} \times \frac{7}{8} = 7.92$

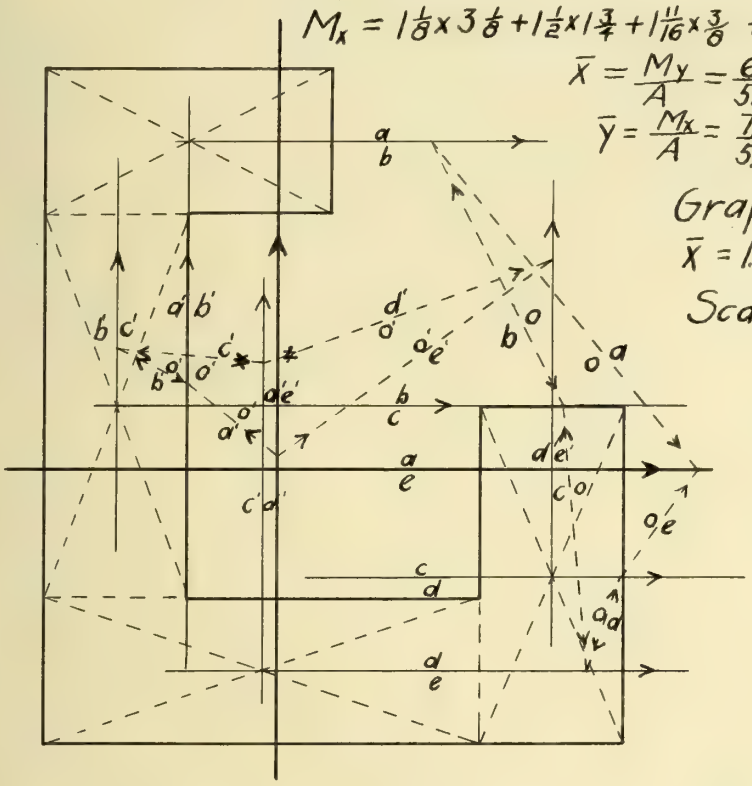
$\bar{x} = \frac{M_y}{A} = \frac{6.75}{5.625} = 1.20''$

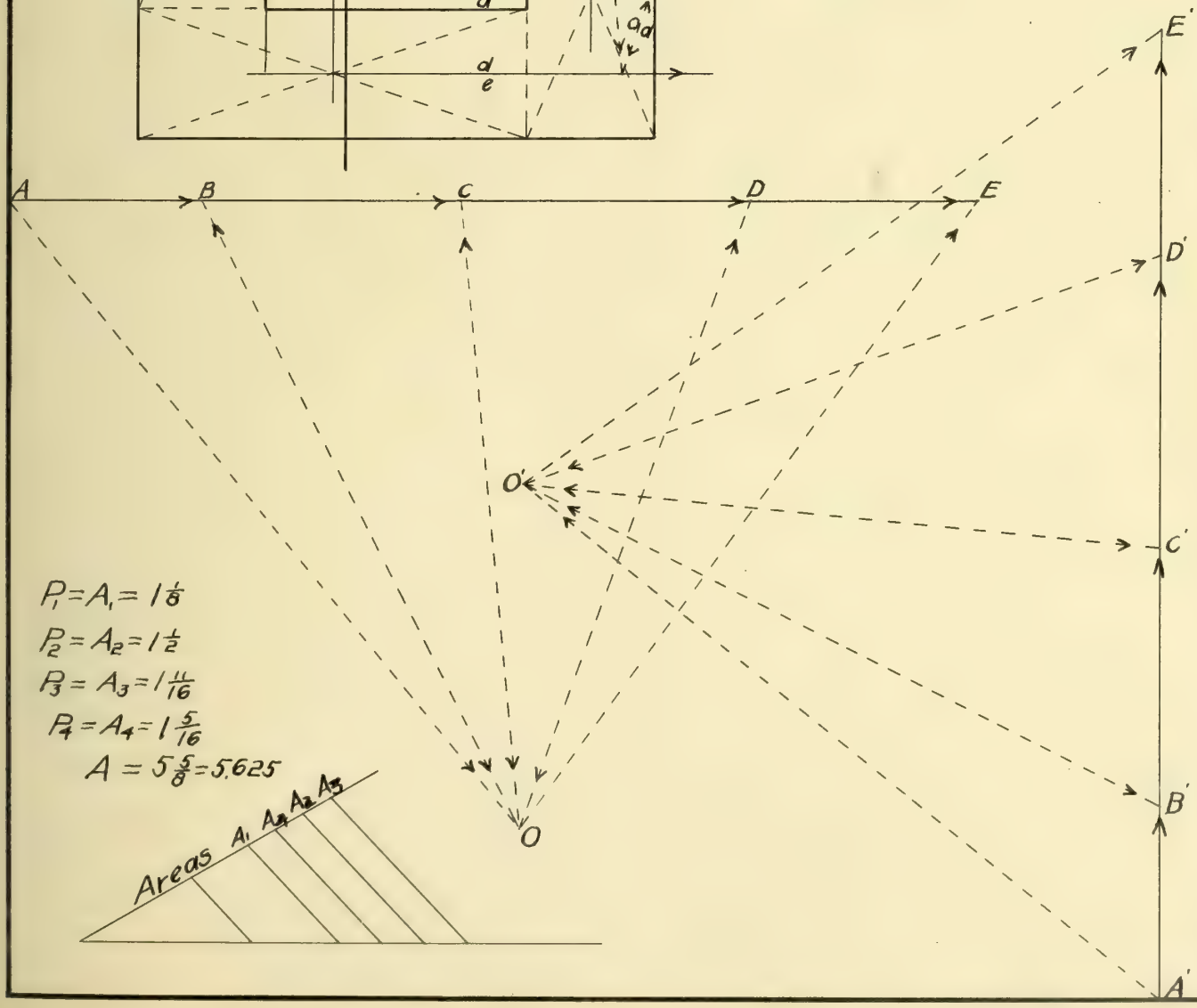
$\bar{y} = \frac{M_x}{A} = \frac{7.92}{5.625} = 1.41''$

Graphic Values.

$\bar{x} = 1.21''$ $\bar{y} = 1.41''$

Scale 1 inch = 1 square inch.





$P_1 = A_1 = 1\frac{1}{8}$

$P_2 = A_2 = 1\frac{1}{2}$

$P_3 = A_3 = 1\frac{11}{16}$

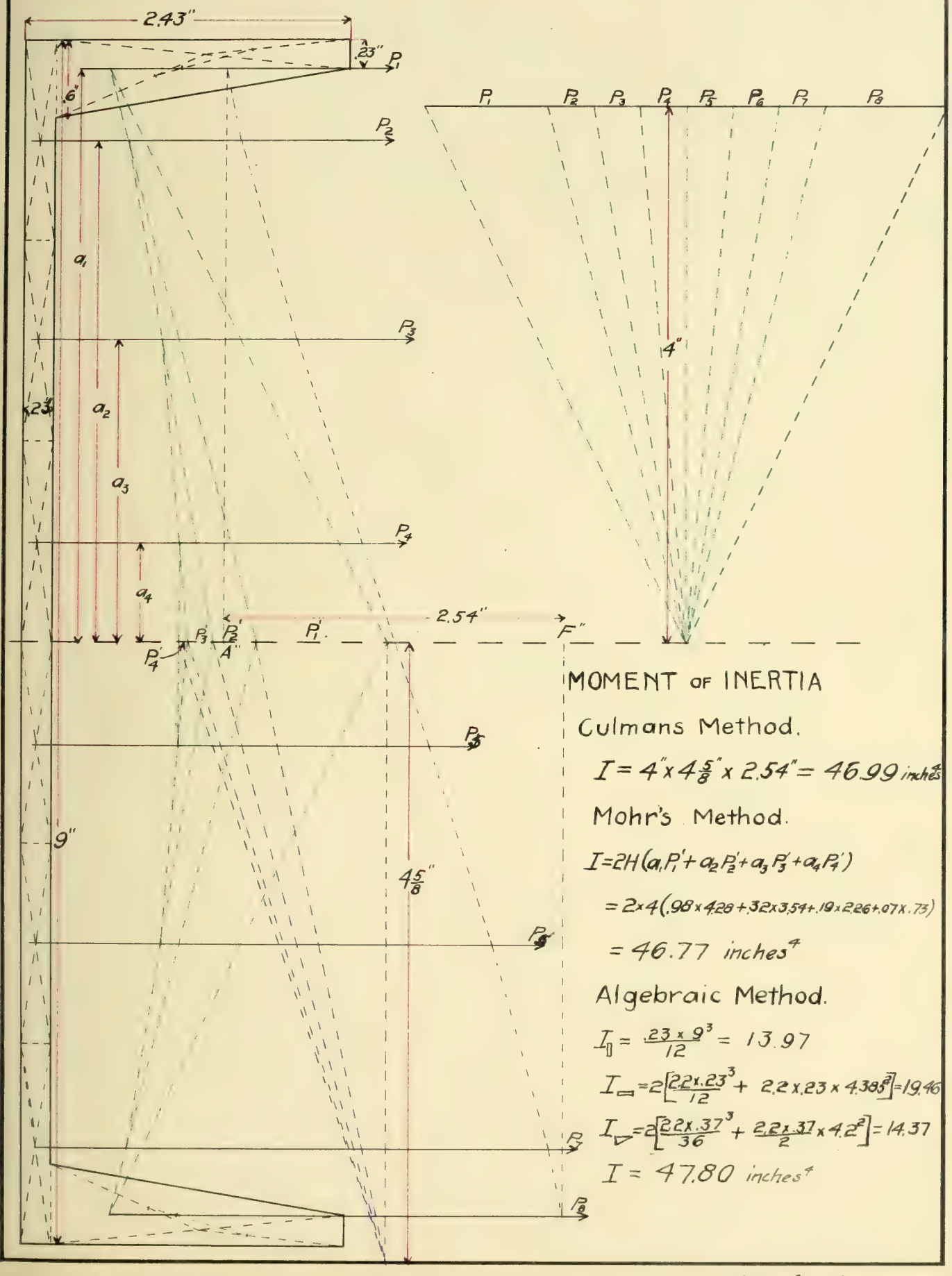
$P_4 = A_4 = 1\frac{5}{16}$

$A = 5\frac{5}{8} = 5.625$

L. E. Curfman.

GRAPHIC STATICS.

Prob. 6.



MOMENT OF INERTIA

Culmans Method.

$I = 4'' \times 4\frac{5}{8}'' \times 2.54'' = 46.99 \text{ inches}^4$

Mohr's Method.

$I = 2H(a_1P_1' + a_2P_2' + a_3P_3' + a_4P_4')$

$= 2 \times 4(.98 \times 4.28 + .32 \times 3.54 + .19 \times 2.26 + .07 \times .73)$

$= 46.77 \text{ inches}^4$

Algebraic Method.

$I_{\square} = \frac{.23 \times 9^3}{12} = 13.97$

$I_{\square} = 2\left[\frac{2.2 \times .23^3}{12} + 2.2 \times .23 \times 4.385^2\right] = 19.46$

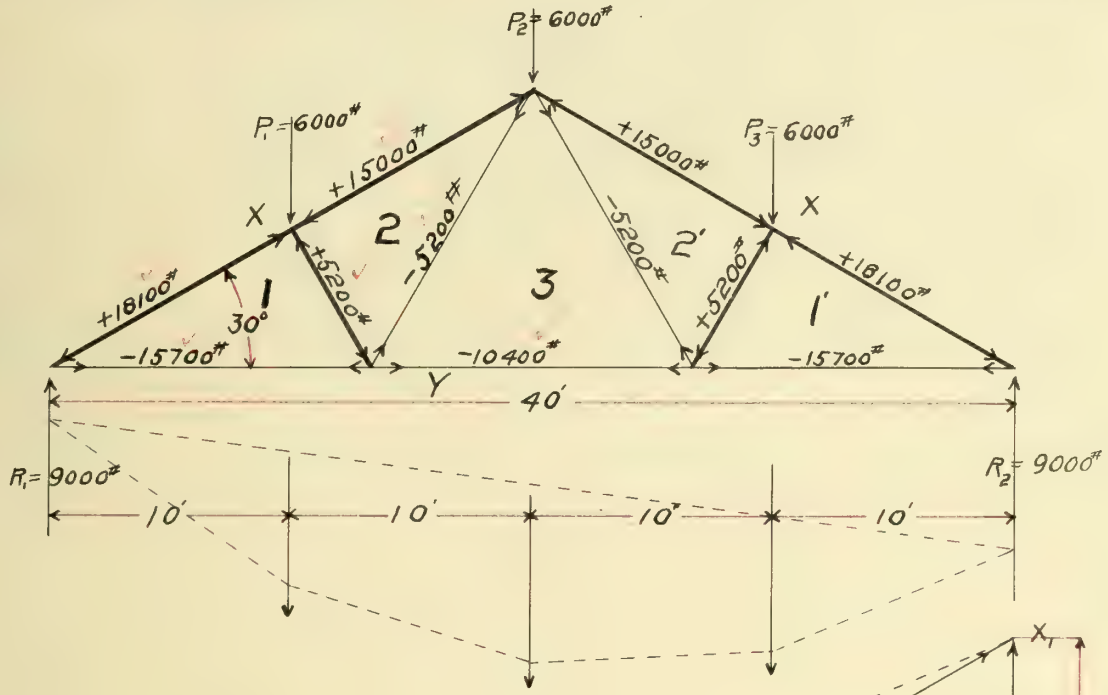
$I_{\triangle} = 2\left[\frac{2.2 \times .37^3}{36} + \frac{2.2 \times .37}{2} \times 4.2^2\right] = 14.37$

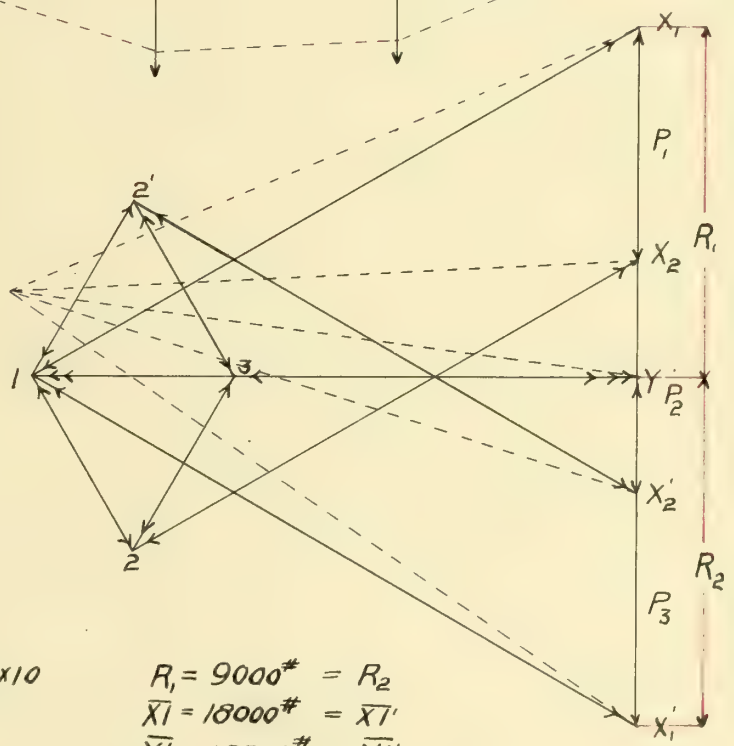
$I = 47.80 \text{ inches}^4$

L. E. Curfman.

GRAPHIC STATICS.

Prob. 7.





$40\,R_1 = 6000\times30 + 6000\times20 + 6000\times10$

$R_1 = 9000^{\#} = R_2$

$\overline{X1} = R_1 \csc 30°$

$\overline{X1} = 18000^{\#} = \overline{X1'}$

$\overline{Y1} = \overline{X1}\cos 30°$

$\overline{Y1} = 15588^{\#} = \overline{Y1'}$

$\overline{X1}\cos 30° = \overline{X2}\cos 30° + \overline{12}\sin 30°$

$6000^{\#} + \overline{X2}\sin 30° = \overline{X1}\sin 30° + \overline{12}\cos 30°$

$\left.\begin{array}{l}\overline{X2} = 15000^{\#} = \overline{X2'} \\ \overline{12} = 5196^{\#} = \overline{12'}\end{array}\right\}$

$\overline{Y1} - \overline{12}\sin 30° = \overline{Y3} + \overline{23}\sin 30°$

$\overline{12}\cos 30° = \overline{23}\cos 30°$

$\left.\begin{array}{l}\overline{Y3} = 10392^{\#} \\ \overline{23} = 5196^{\#} = \overline{23}\end{array}\right\}$

$6000 = 2(\overline{X2}\sin 30° - \overline{23}\cos 30°)$ Check.

Trusses spaced 15 ft. apart.

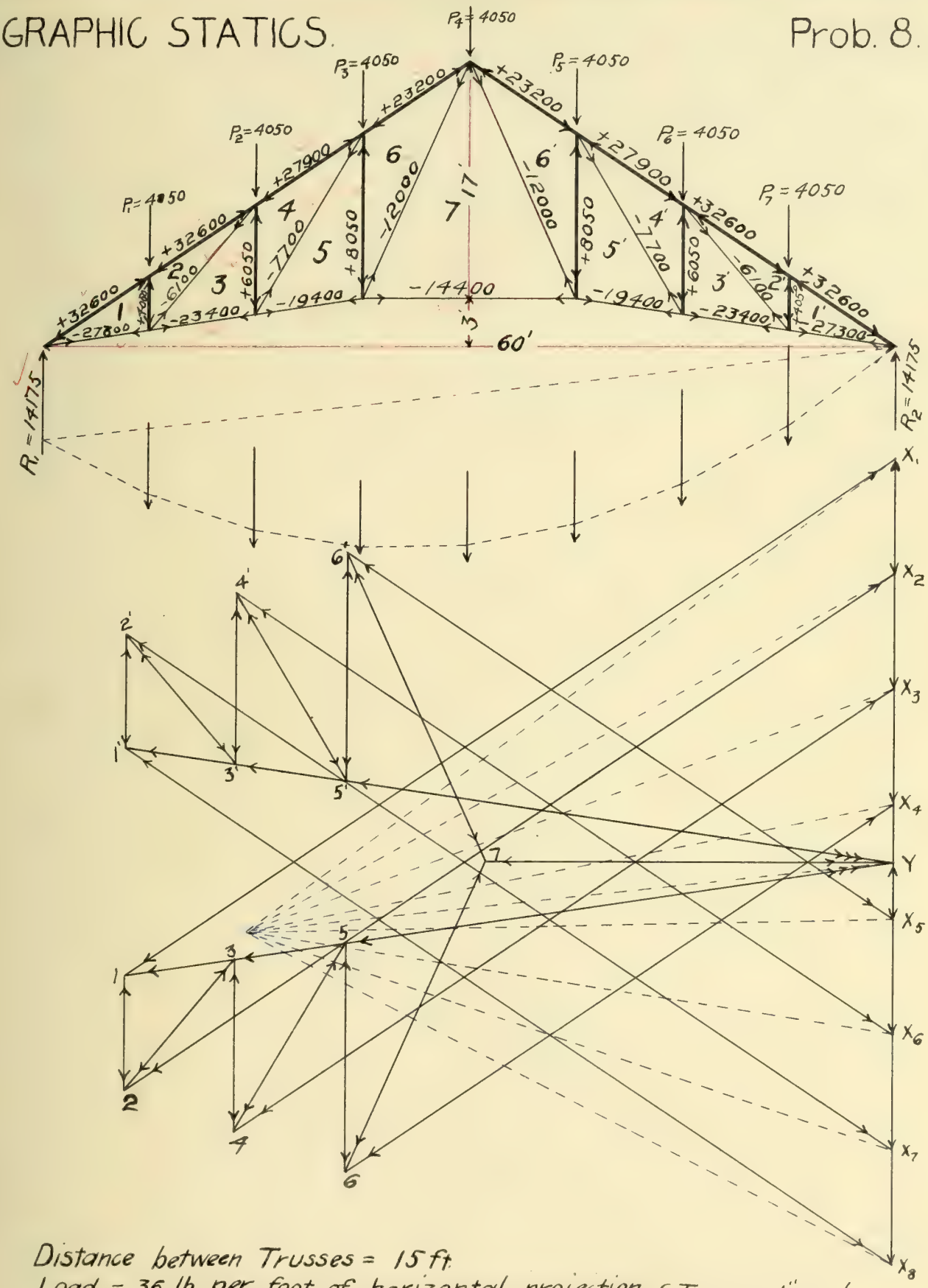
Load = 40# per square foot horizontal projection.

Scale { Truss 1" = 8'.
Loads 1" = 5000#.

L. E. Curfman.

GRAPHIC STATICS.

Prob. 8.



Distance between Trusses = 15 ft.
Load = 36 lb. per foot of horizontal projection.
Scales { Truss 1" = 10'
Loads 1" = 5000 lb.

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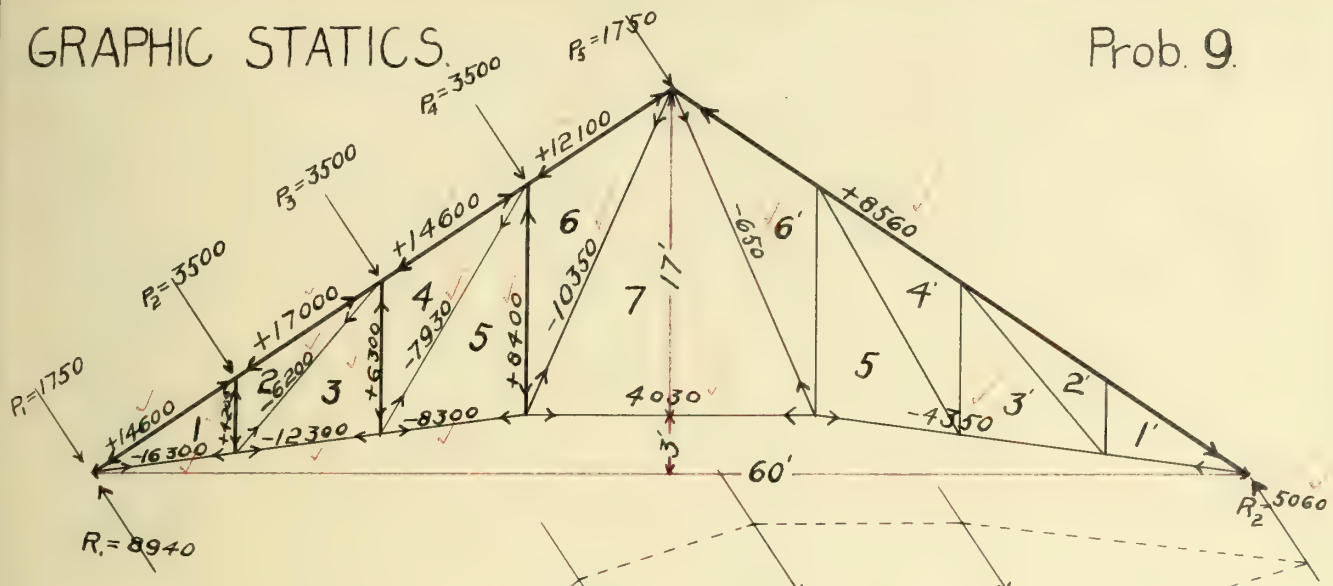
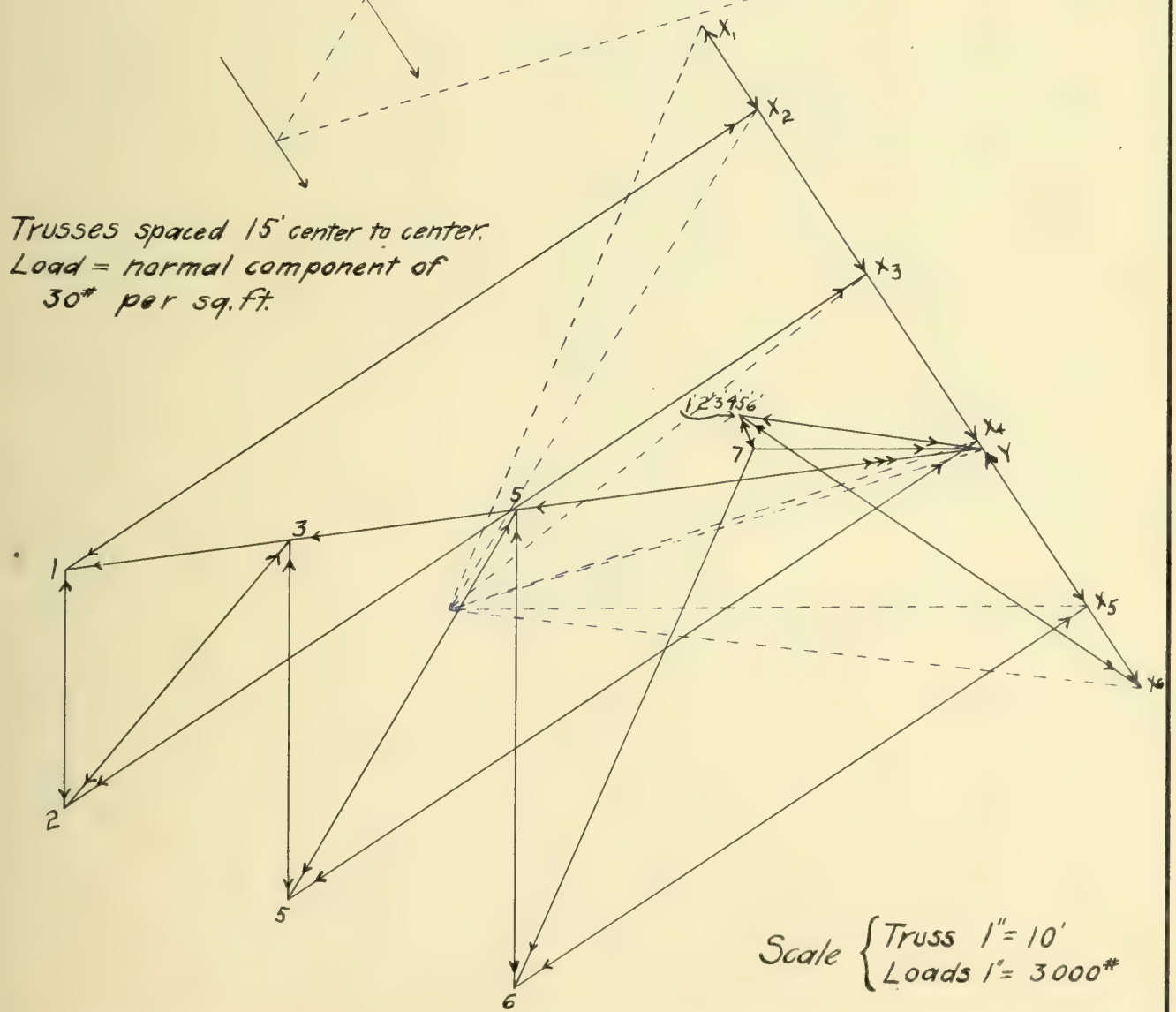
GRAPHIC STATICS.

Prob. 9.





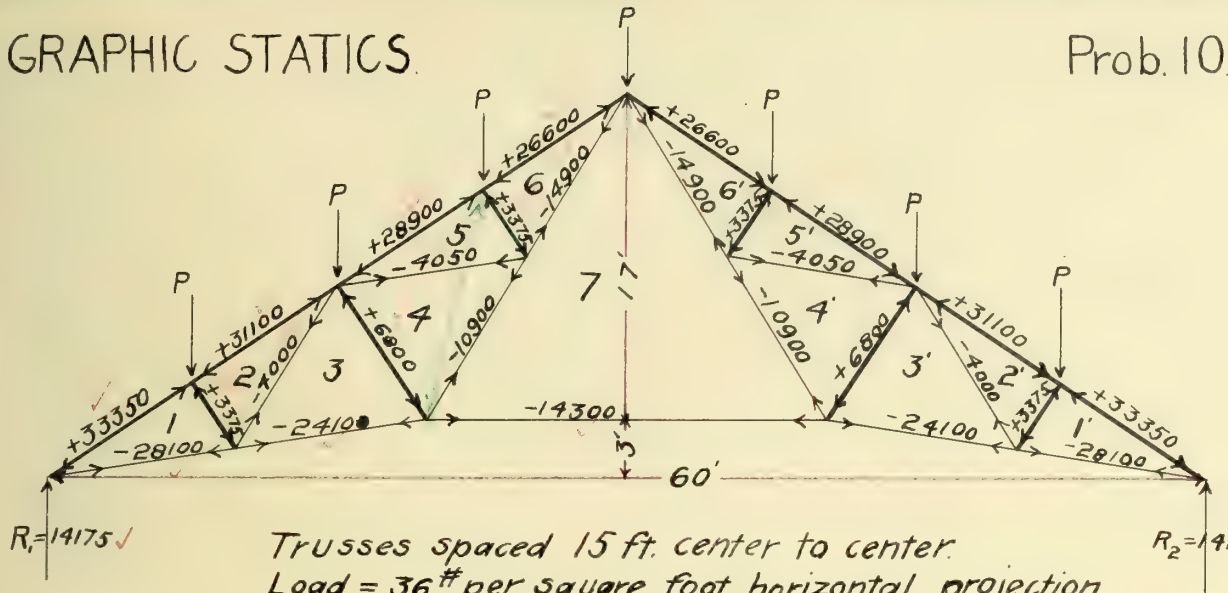
Trusses spaced 15' center to center.
Load = normal component of
30# per sq. ft.

Scale { Truss 1" = 10'
Loads 1" = 3000#

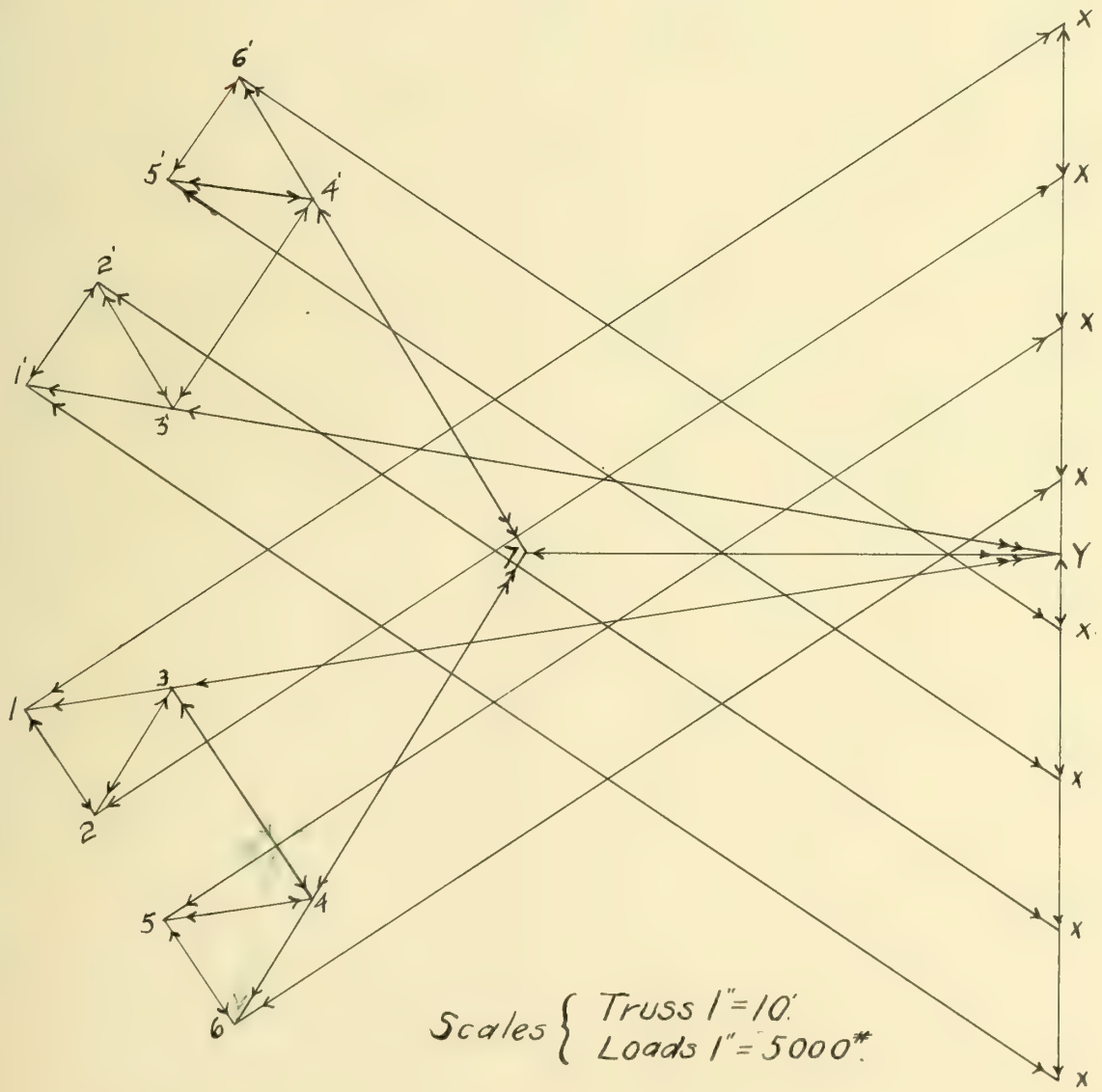
L. E. Cunfman

GRAPHIC STATICS

Prob. 10



Trusses spaced 15 ft. center to center.
Load = 36# per square foot horizontal projection.
$P = 7\frac{1}{2} \times 15 \times 36^{\#} = 4050^{\#}$

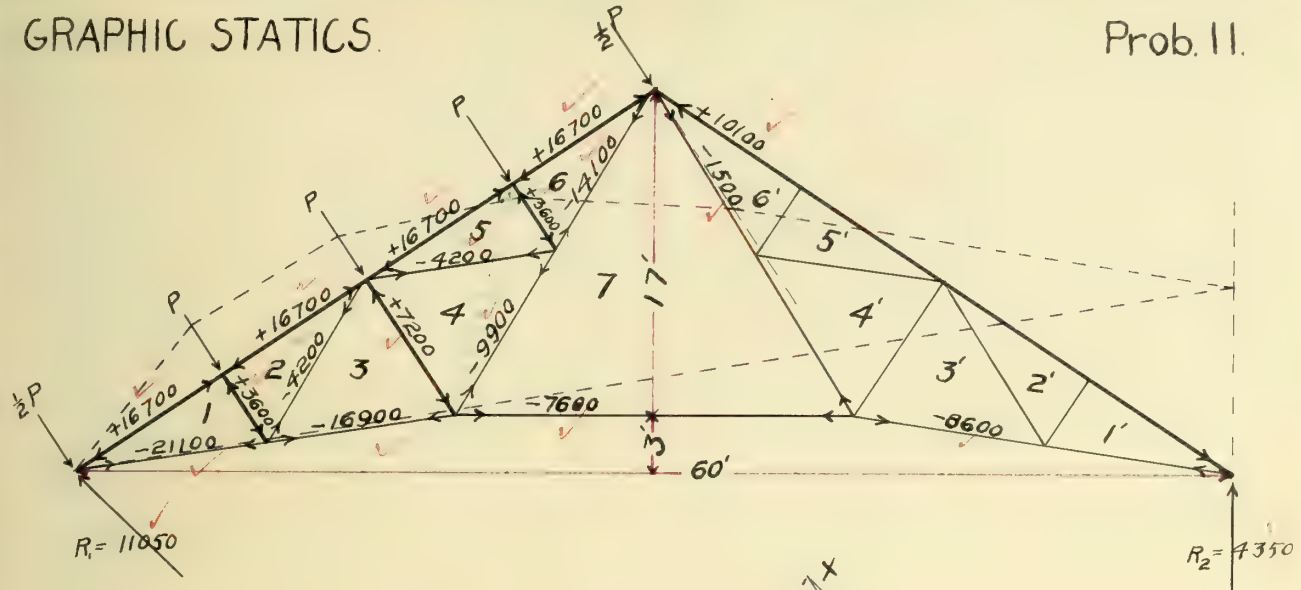


Scales { Truss 1" = 10'
Loads 1" = 5000#

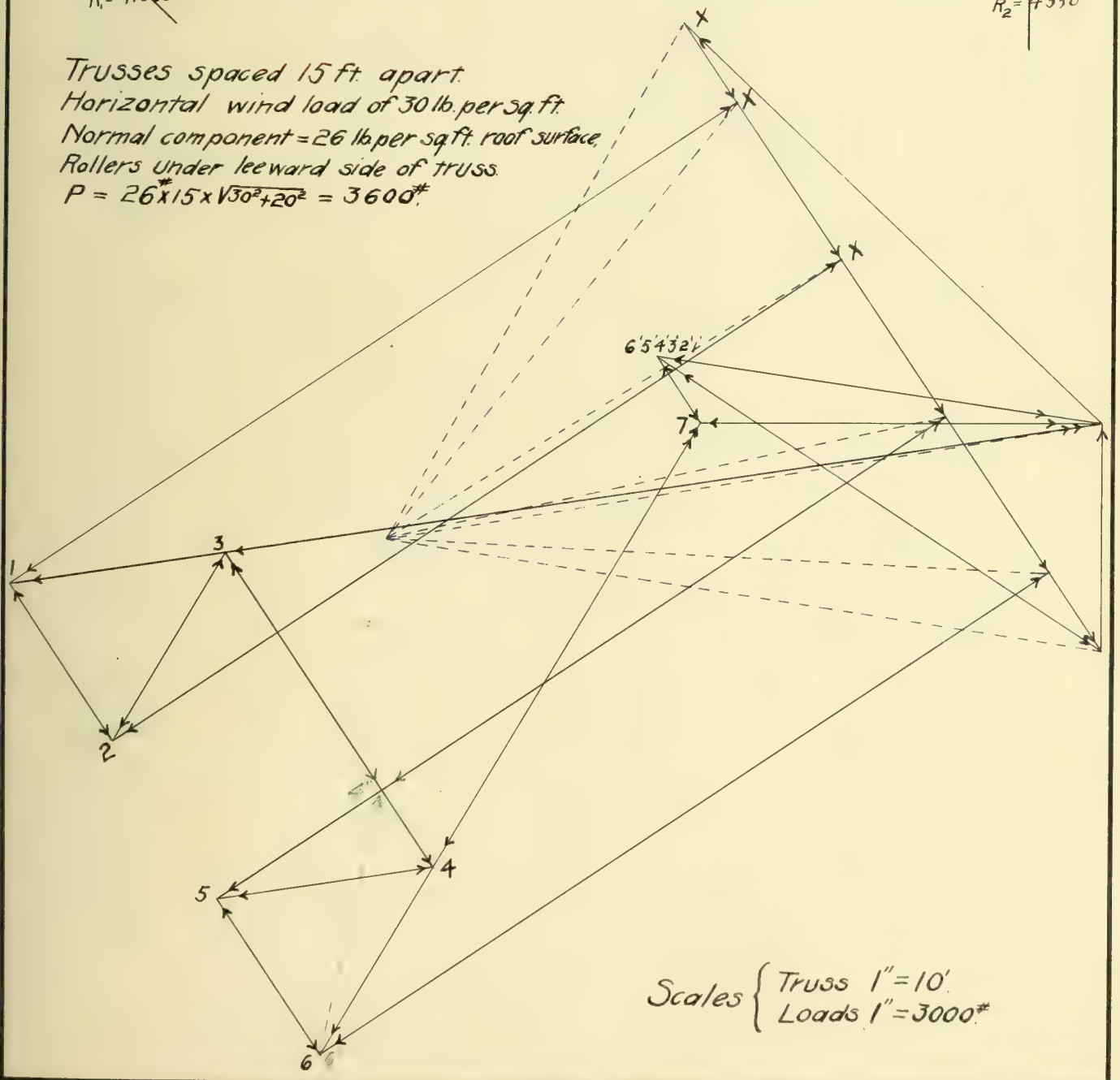
L. E. Curfman

GRAPHIC STATICS.

Prob. 11.



Trusses spaced 15 ft. apart.
Horizontal wind load of 30 lb. per sq. ft.
Normal component = 26 lb. per sq. ft. roof surface.
Rollers under leeward side of truss.
$P = 26^{\#} \times 15 \times \sqrt{30^2+20^2} = 3600^{\#}$.



Scales { Truss 1" = 10'
Loads 1" = 3000#

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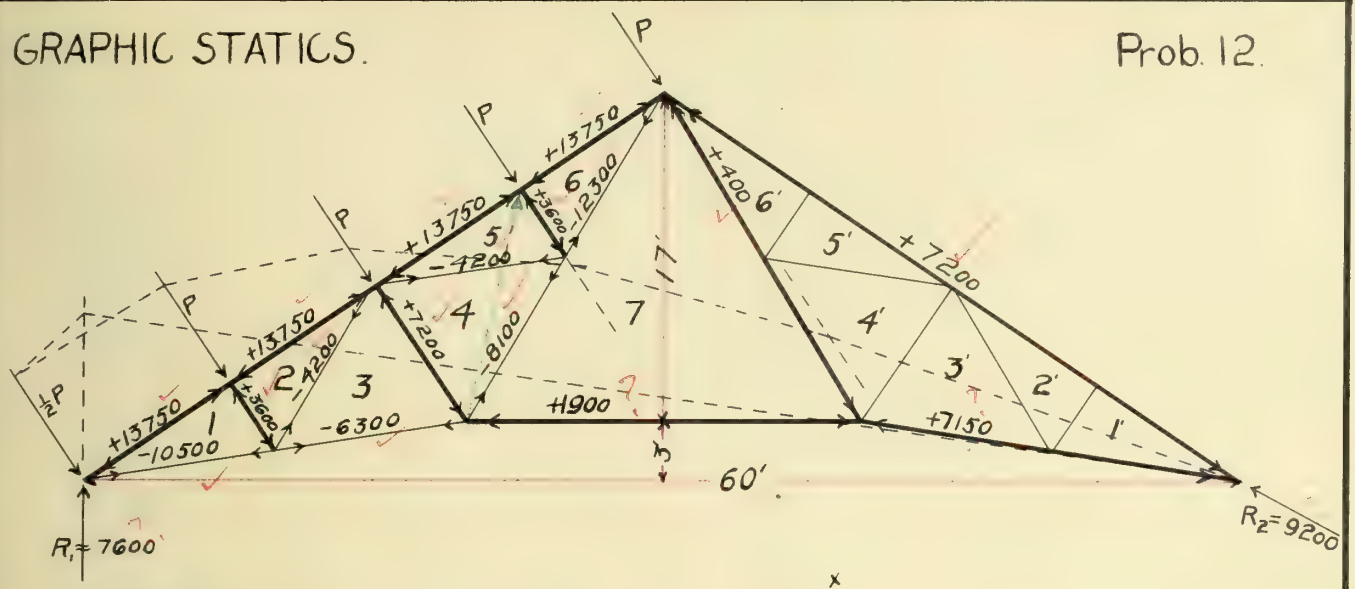
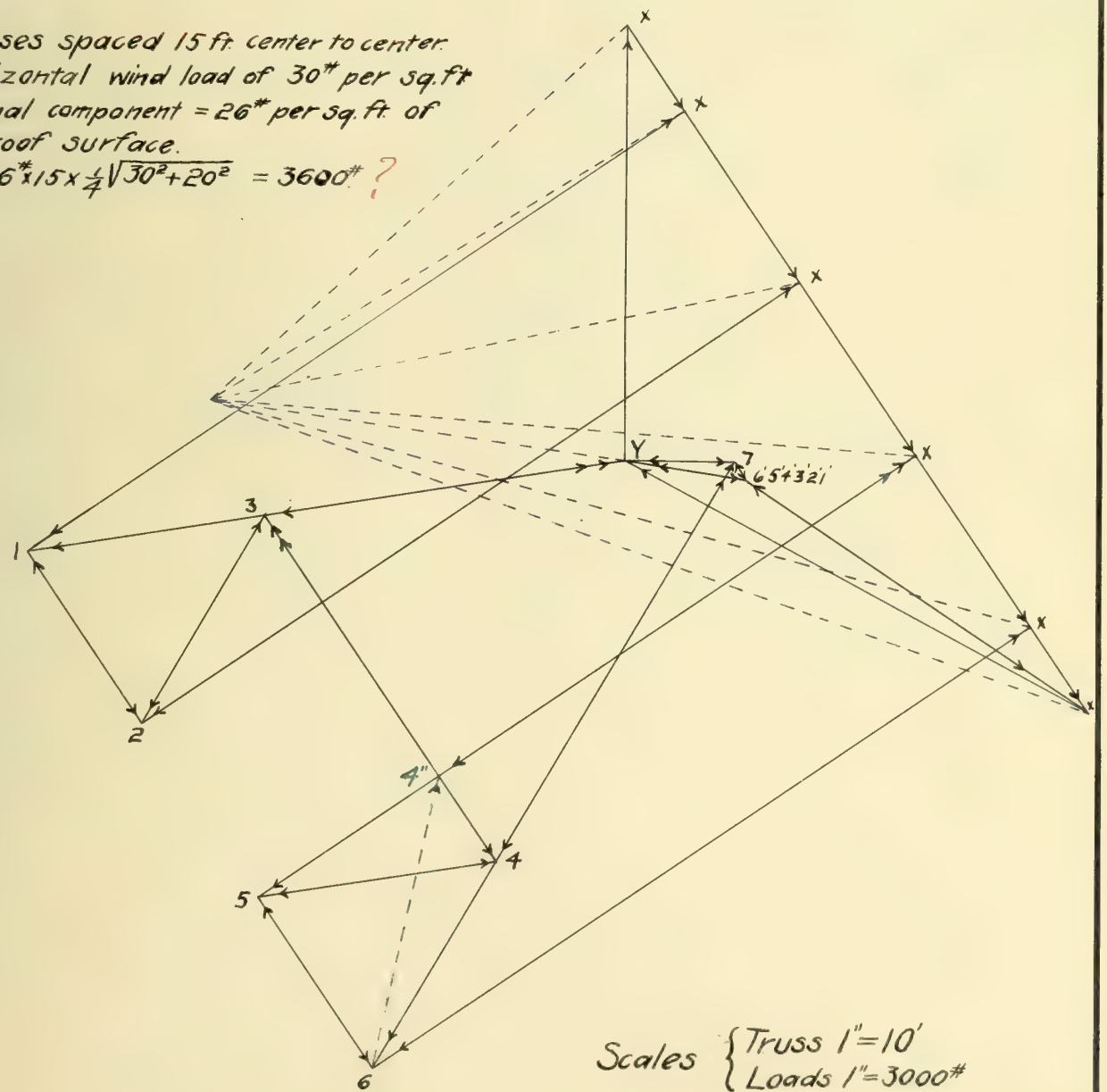
GRAPHIC STATICS.

Prob. 12.



Trusses spaced 15 ft. center to center.
Horizontal wind load of 30# per sq. ft.
Normal component = 26# per sq. ft. of roof surface.

$P = 26^{\#} \times 15 \times \frac{1}{4}\sqrt{30^2+20^2} = 3600^{\#}$?



Scales { Truss 1"=10'
Loads 1"=3000#

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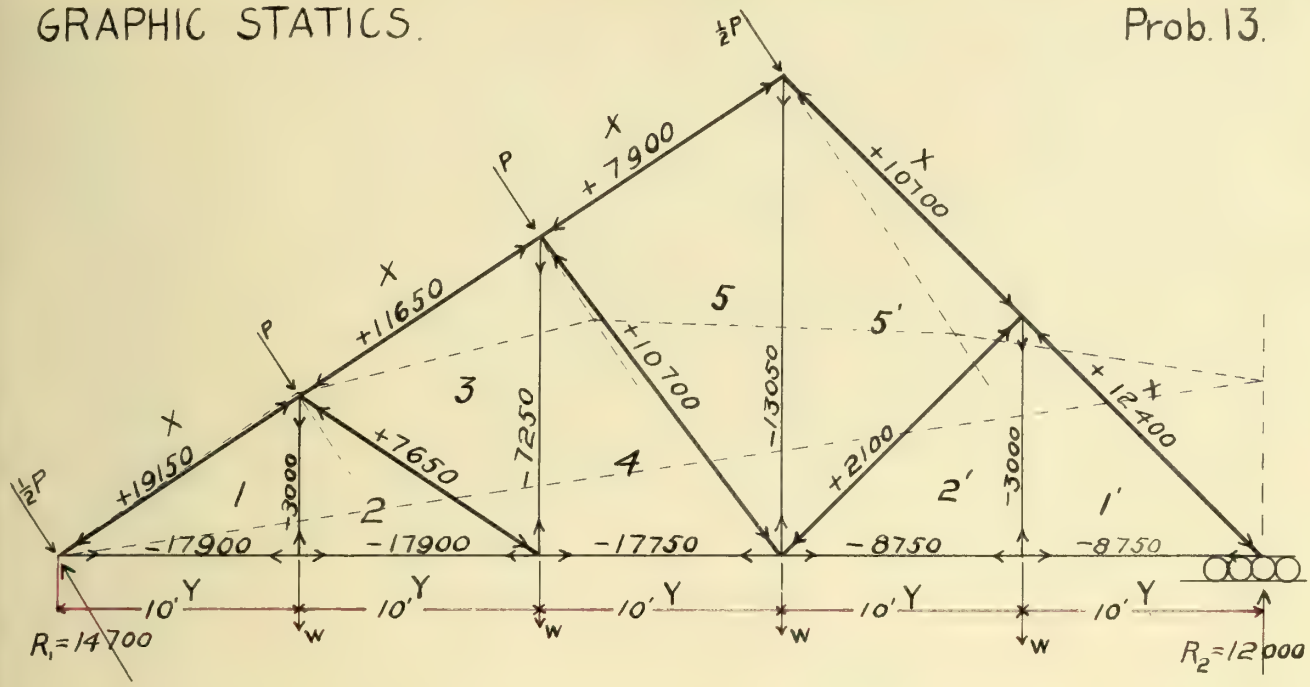
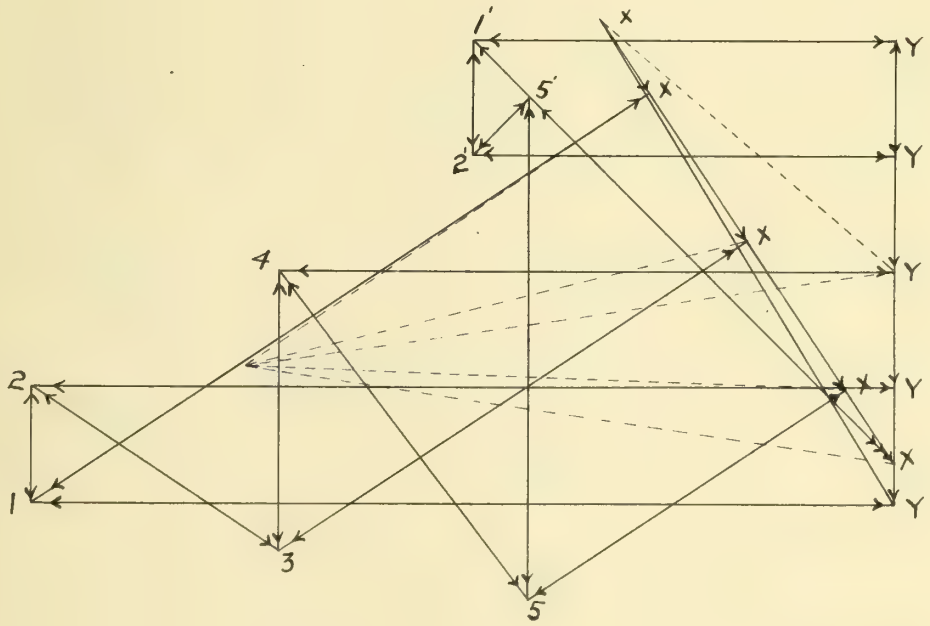
GRAPHIC STATICS.

Prob. 13.



Pitch on left side = ⅓ Scale 1" = 8'

P = 4600# W = 3000#



Scale 1" = 5000#

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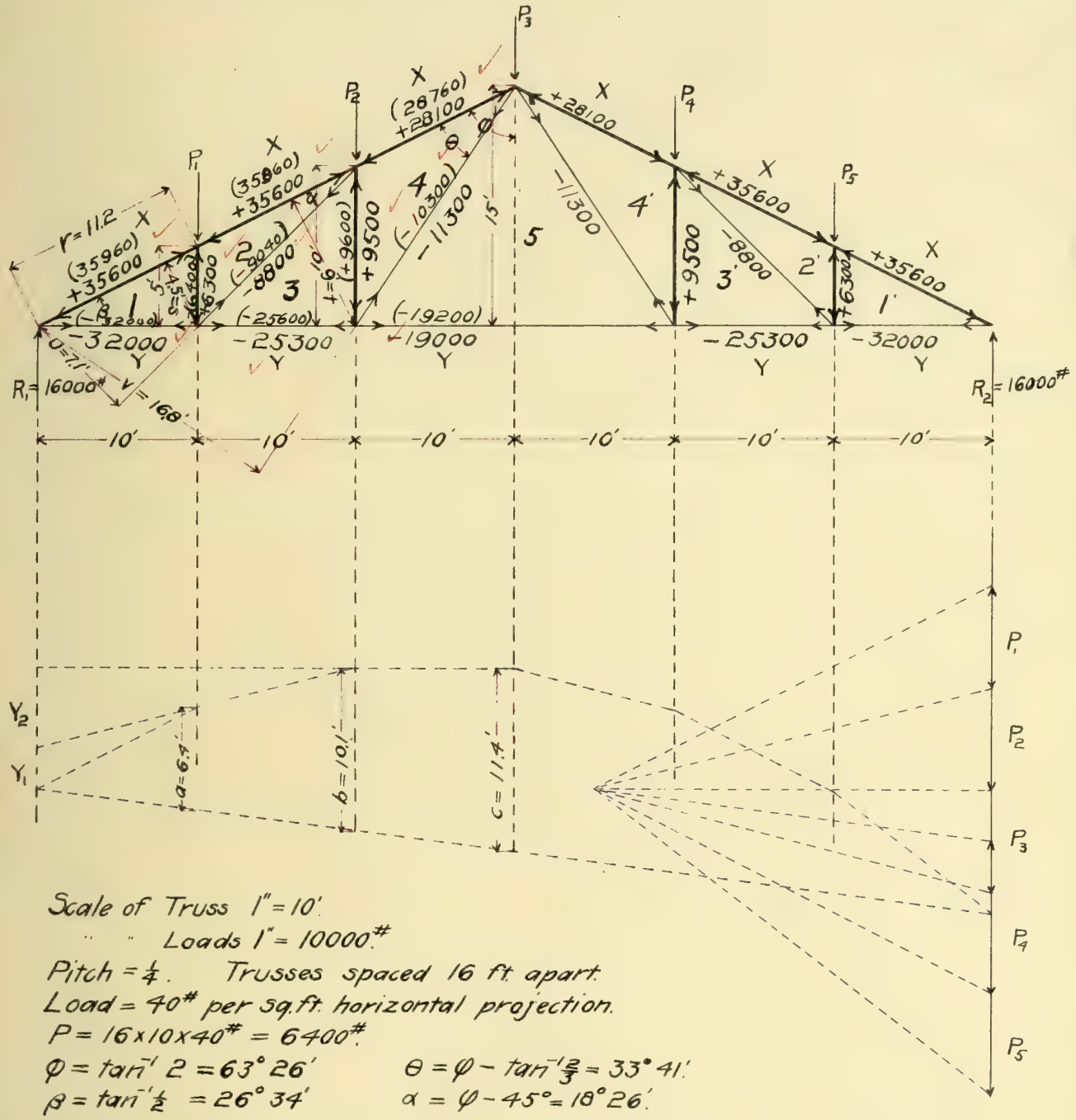
GRAPHIC STATICS.

Prob. 14.



Scale of Truss 1" = 10'.
" " Loads 1" = 10000#.
Pitch = $\frac{1}{4}$. Trusses spaced 16 ft. apart.
Load = 40# per sq. ft. horizontal projection.
$P = 16 \times 10 \times 40\# = 6400\#$.

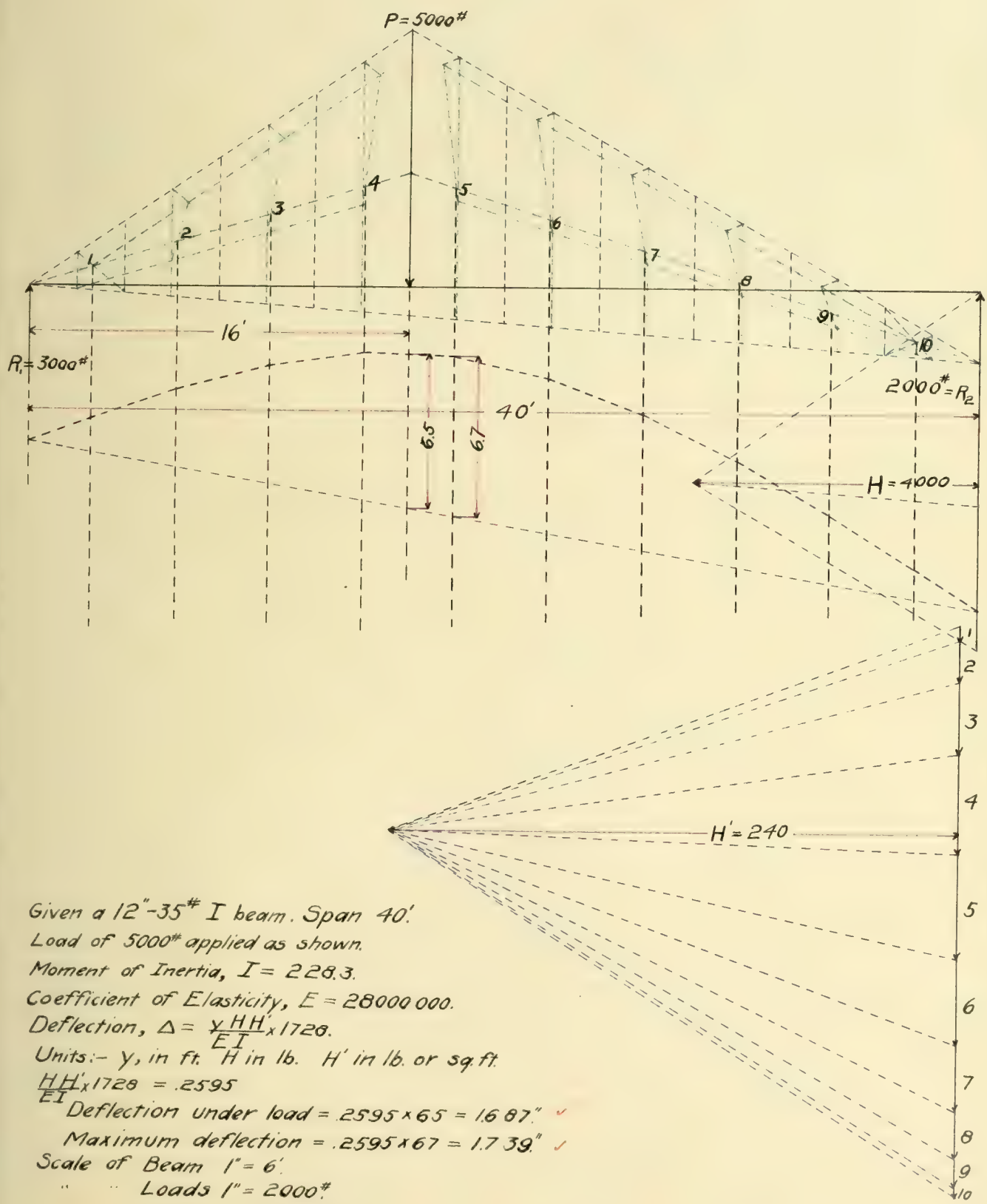
$\varphi = \tan^{-1} 2 = 63° 26'$ $\quad \theta = \varphi - \tan^{-1}\frac{2}{3} = 33° 41'$.
$\beta = \tan^{-1}\frac{1}{2} = 26° 34'$ $\quad \alpha = \varphi - 45° = 18° 26'$.
$s = 10 \sin\beta = 4.45'$ $\quad t = 2s = 8.89$ $\quad U = 2r\sin\alpha = 7.08'$ $\quad V = 3r\sin\theta = 18.58'$.

$\overline{X1} \times S - 10 \times R_1 = 0.$	$\overline{X1} = +35960.$	$\overline{X1} = \frac{a}{s} \times H = +35600.$
$\overline{X2} \times S - 10 \times R_1 = 0.$	$\overline{X2} = +35960.$	$\overline{X2} = \frac{a}{s} \times H = +35600.$
$\overline{X3} \times t - 20 \times R_1 + 10 \times P_1 = 0.$	$\overline{X3} = +28760.$	$\overline{X4} = \frac{b}{t} \times H = +28100.$
$-\overline{Y1} \times 5 - 10 \times R_1 = 0.$	$\overline{Y1} = -32000.$	$\overline{Y1} = \frac{a}{12} \times H = -32000.$
$-\overline{Y2} \times 10 - 20 \times R_1 + 10 \times P_1 = 0.$	$\overline{Y3} = -25600.$	$\overline{Y3} = b \times H = -25300.$
$-\overline{Y5} \times 15 - 30 \times R_1 + 20 \times P_1 + 10 \times P_2 = 0.$	$\overline{Y5} = -19200.$	$\overline{Y5} = \frac{c}{15} \times H = -19000.$
$\overline{12} \times 10 - 10 \times P_1 = 0.$	$\overline{12} = +6400.$	$\overline{12} = \frac{Y_1}{10} \times H = +6300.$
$\overline{34} \times 20 - 10 \times P_1 - 20 \times P_2 = 0.$	$\overline{34} = +9600.$	$\overline{34} = \frac{Y_1 + Y_2}{20} \times H = +9500.$
$\overline{23} \times U - 10 \times P_1 = 0.$	$\overline{23} = -9040.$	$\overline{23} = \frac{Y_1 \times 10}{U} \times H = -8800.$
$\overline{45} \times V - 10 \times P_1 - 20 \times P_2 = 0.$	$\overline{45} = -10300.$	$\overline{45} = \frac{Y_1 \times 10 + Y_2 \times 20}{V} \times H = -11300.$

L. E. Curfman.

GRAPHIC STATICS

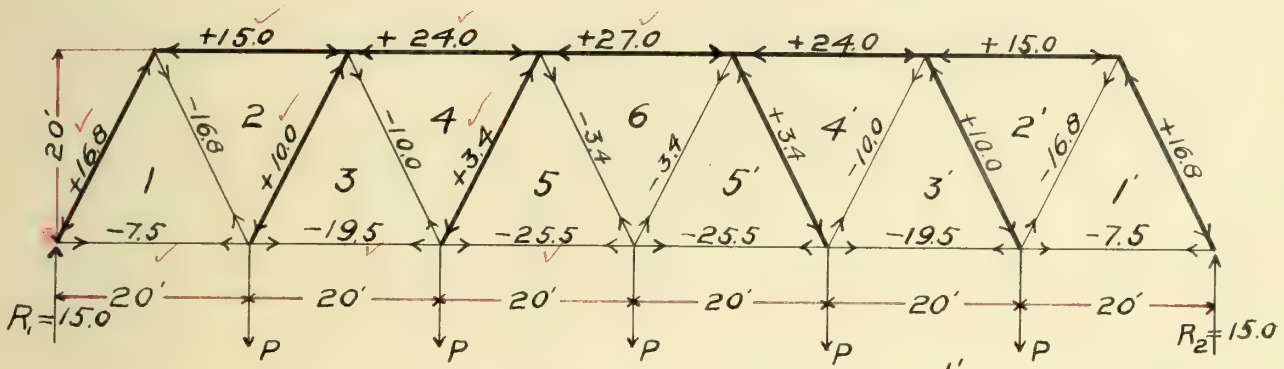
Prob. 15.



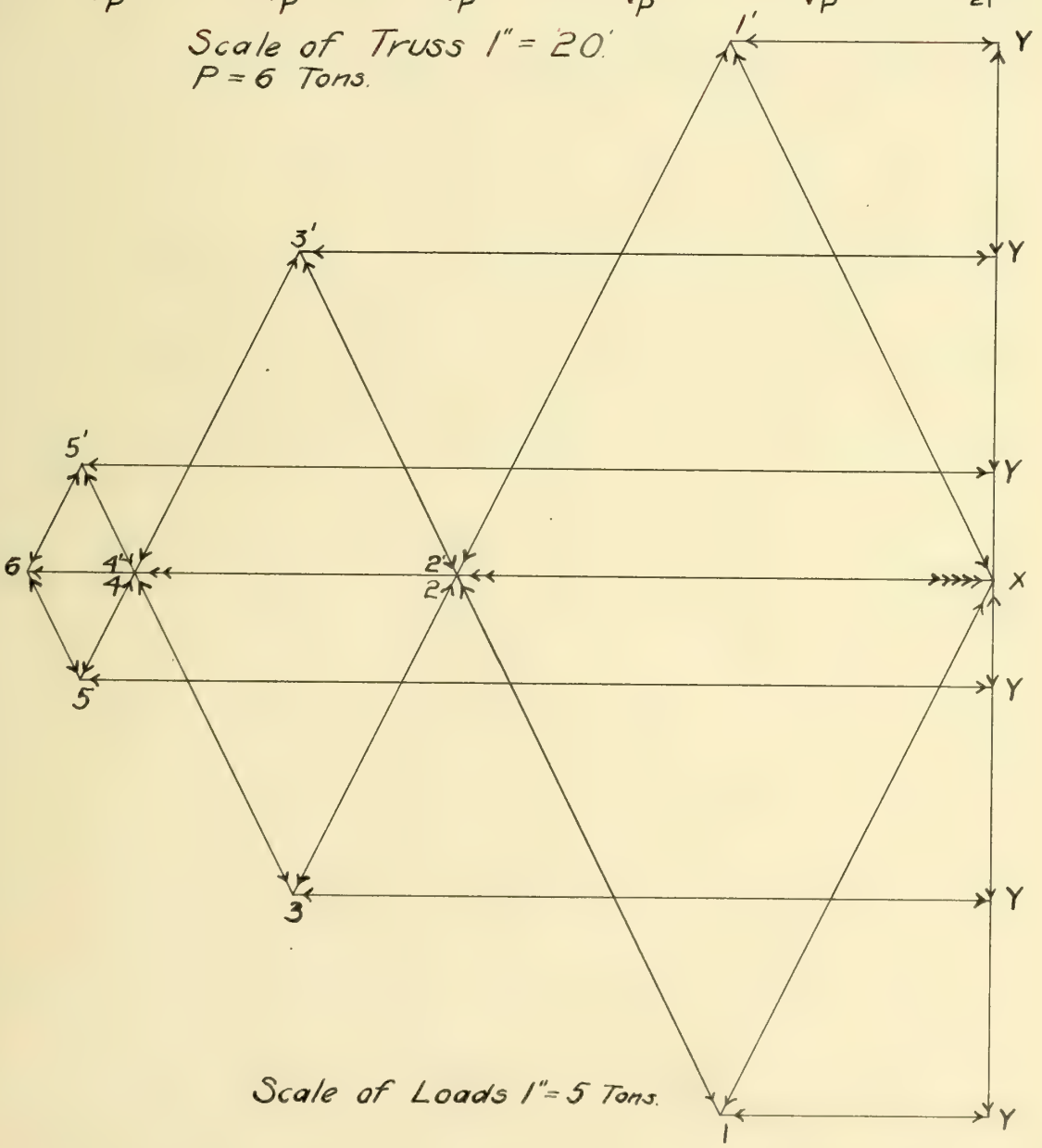
Given a 12"-35# I beam. Span 40'.
Load of 5000# applied as shown.
Moment of Inertia, $I = 228.3$.
Coefficient of Elasticity, $E = 28000000$.
Deflection, $\Delta = \frac{y}{EI} \frac{HH'}{} \times 1728$.
Units:- y, in ft. H in lb. H' in lb. or sq. ft.
$\frac{HH'}{EI} \times 1728 = .2595$
Deflection under load = $.2595 \times 65 = 1.687$" ✓
Maximum deflection = $.2595 \times 67 = 1.739$" ✓
Scale of Beam 1" = 6'
" " Loads 1" = 2000#
" " Areas 1" = 60 sq. ft.

L. E. Curfman.

GRAPHIC STATICS. Prob. 16



Scale of Truss 1" = 20'
P = 6 Tons.

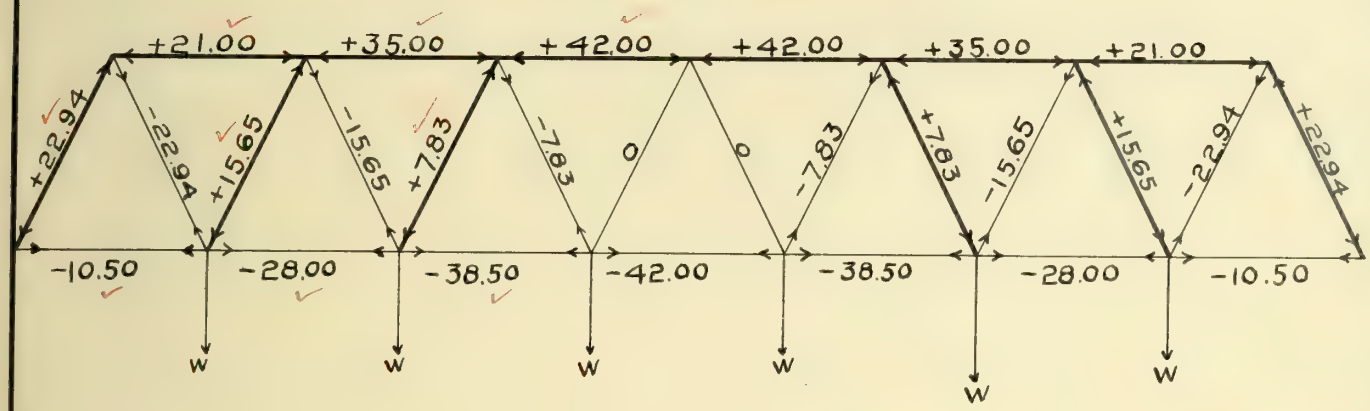


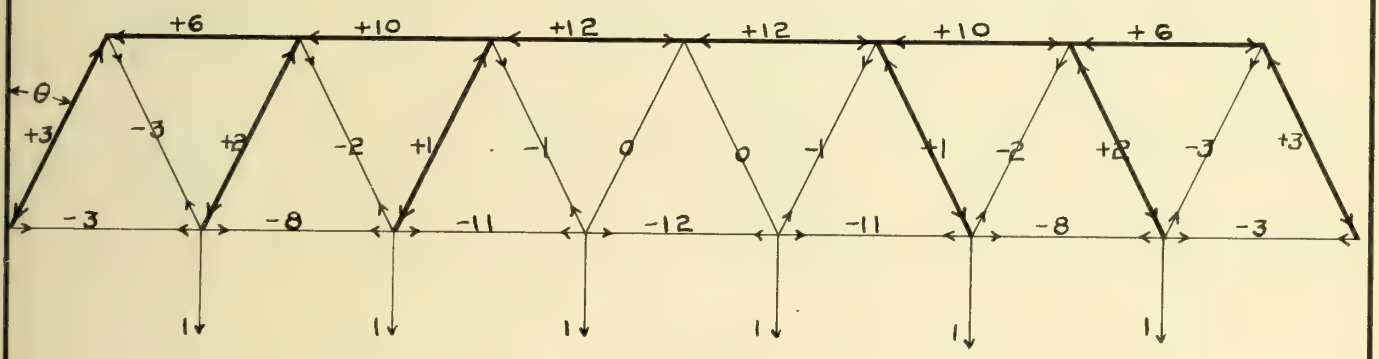
Scale of Loads 1" = 5 Tons.

L. E. Curfman

GRAPHIC STATICS.

Prob. 17.





Span = 140' L = 20' d = 20'

W = 7 tons. n = 7

Scale of Truss 1" = 20'

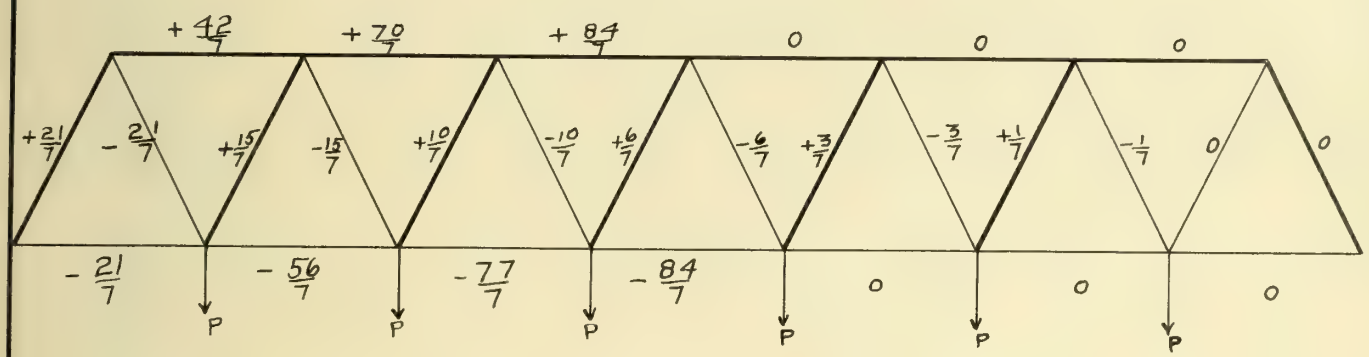
W tan θ = 3.50 tons W sec θ = 7.83 tons.

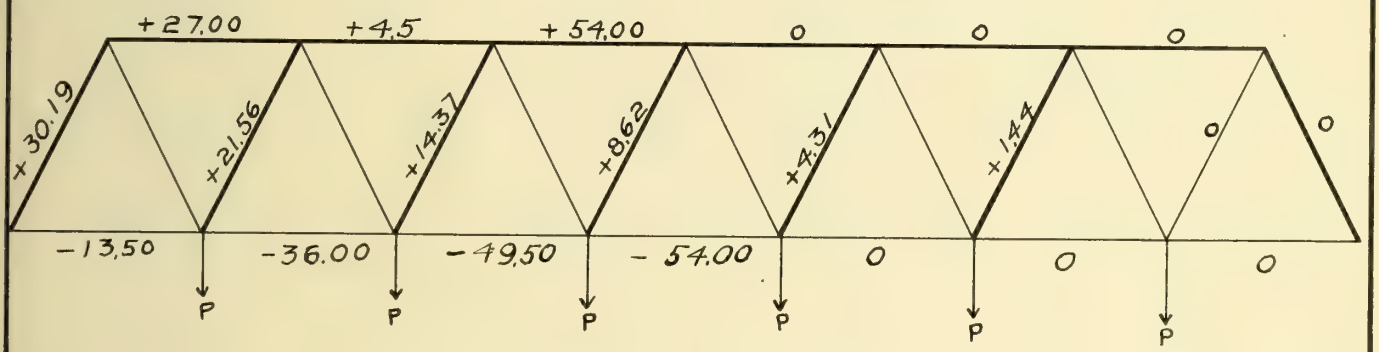
L. E. Burpman

MAY 28

GRAPHIC STATICS.

Prob. 18.





Span = 140' d = 20'

L = 20' P = 9 tons.

tan θ = 0.5 P tan θ = 4.5 sec θ = 1.118 P sec θ = 10.06

Maximum stresses shown on left side of truss.

Minimum on the right half.

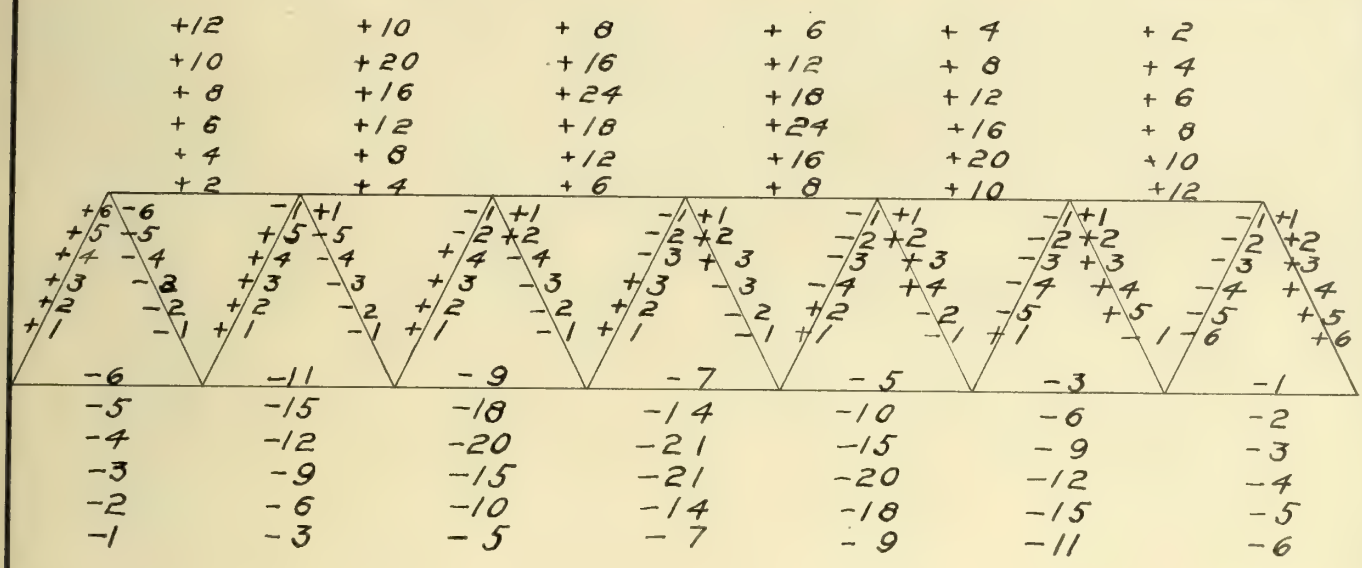
Entire load passing onto truss from one end.

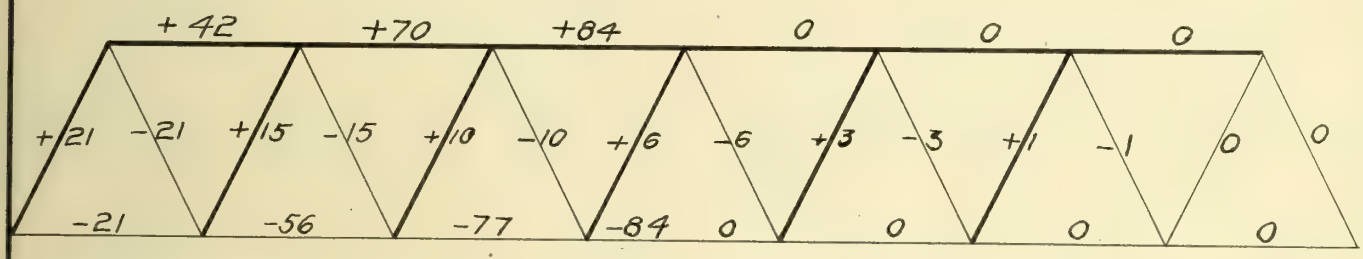
L. E. Curfman

MAY 26 1911

GRAPHIC STATICS.

Prob. 19.





Maximum Minimum

Span = 140′ L = 20′ d = 20′ n = 7.

Upper truss shows coefficients for concentrated load on joints in succession.

Lower truss shows coefficients for maximum and minimum stresses for uniform live load.

NOTE:—Coefficients should all be divided by 7; i.e., they are sevenths.

L. E. Cushman

Graphic Statics

Prob 1

Five concurrent forces

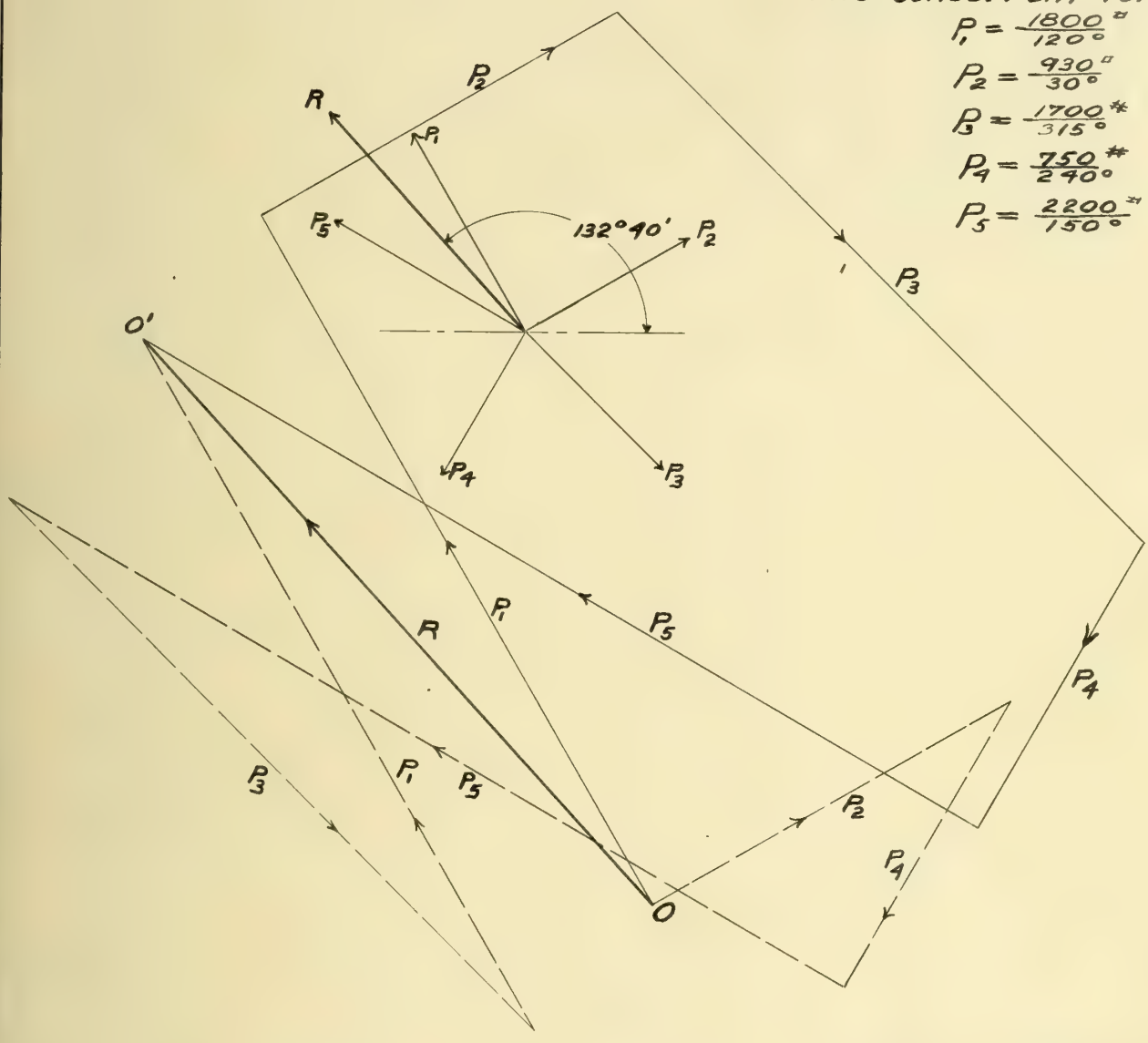
$P_1 = \frac{1800^{\#}}{120°}$

$P_2 = \frac{930^{\#}}{30°}$

$P_3 = \frac{1700^{\#}}{315°}$

$P_4 = \frac{750^{\#}}{240°}$

$P_5 = \frac{2200^{\#}}{150°}$



Scale 1" = 400#

Algebraic Solution of Resultant

$R^2 = \overline{\Sigma X}^2 + \overline{\Sigma Y}^2 \qquad \theta = \tan^{-1}\frac{\Sigma Y}{\Sigma X}$

$\Sigma X = P_1\cos 120° + P_2\cos 30° + P_3\cos 315° + P_4\cos 240° + P_5\cos 150°$

$\Sigma Y = P_1\sin 120° + P_2\sin 30° + P_3\sin 315° + P_4\sin 240° + P_5\sin 150°$

Results Algebraic

$R = 1729.6'$ $\qquad \theta = 132°\,39'$

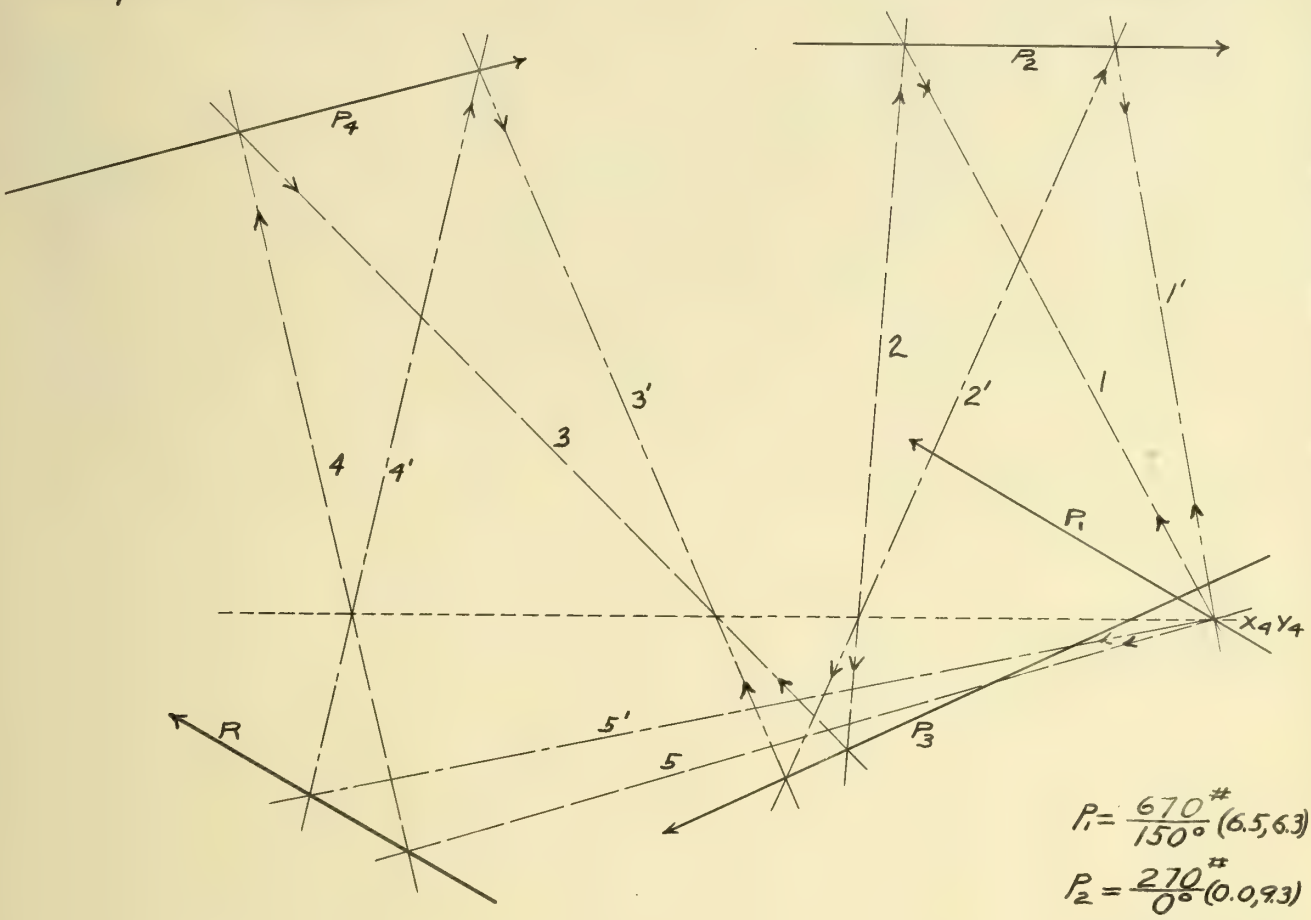
Results Graphic

$R = 1730$ $\qquad \theta = 132°\,40'$

JE Shoemaker

Graphic Statics

Prob 2



$P_1 = \frac{670^{\#}}{150^\circ}$ (6.5, 6.3)

$P_2 = \frac{270^{\#}}{0^\circ}$ (0.0, 9.3)

$P_3 = \frac{350^{\#}}{205^\circ}$ (6.5, 6.6)

$P_4 = \frac{210^{\#}}{15^\circ}$ (0.3, 8.5)

$X_1Y_1 = (6.7, 1.0)$

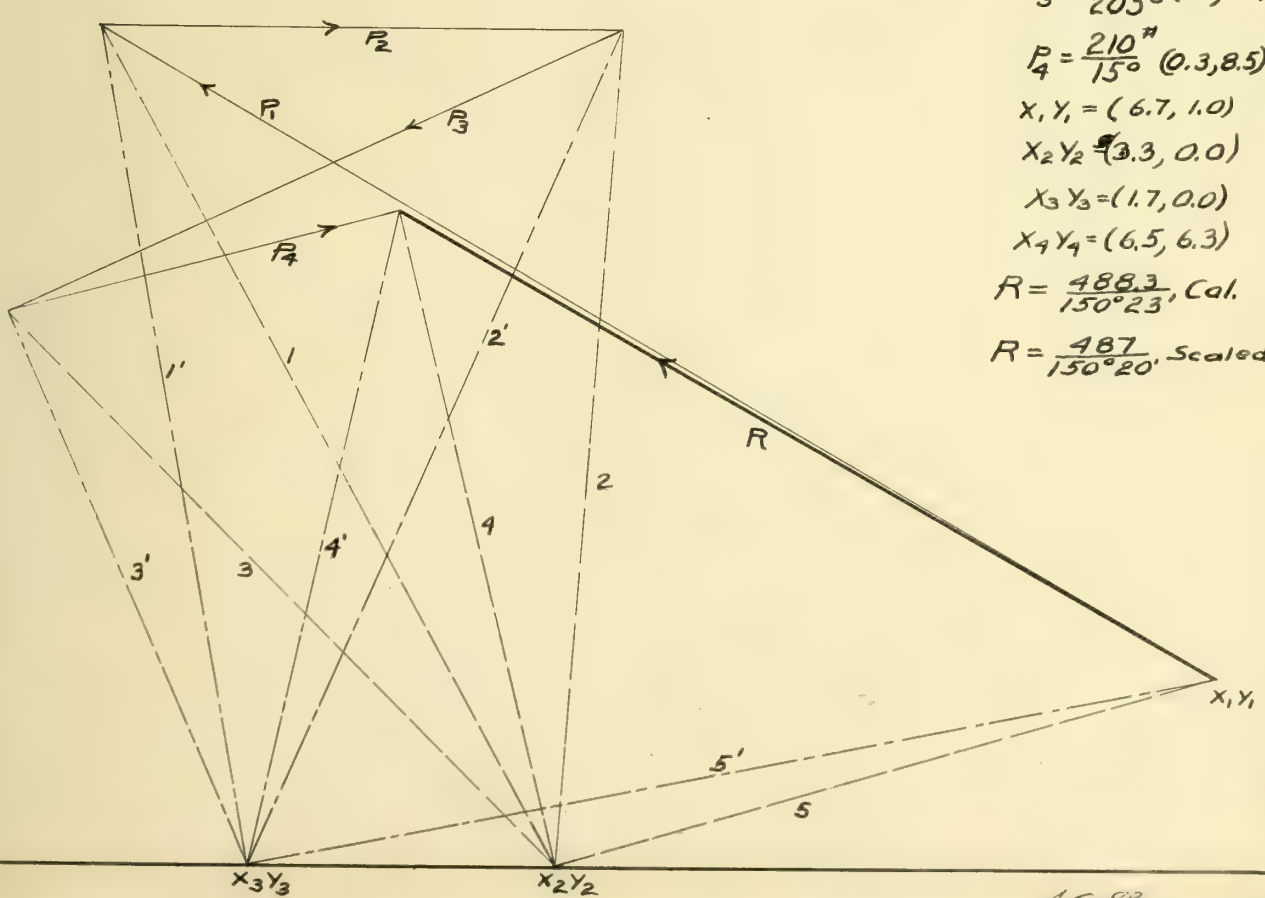
$X_2Y_2 = (3.3, 0.0)$

$X_3Y_3 = (1.7, 0.0)$

$X_4Y_4 = (6.5, 6.3)$

$R = \frac{488.3}{150^\circ 23'}$, Cal.

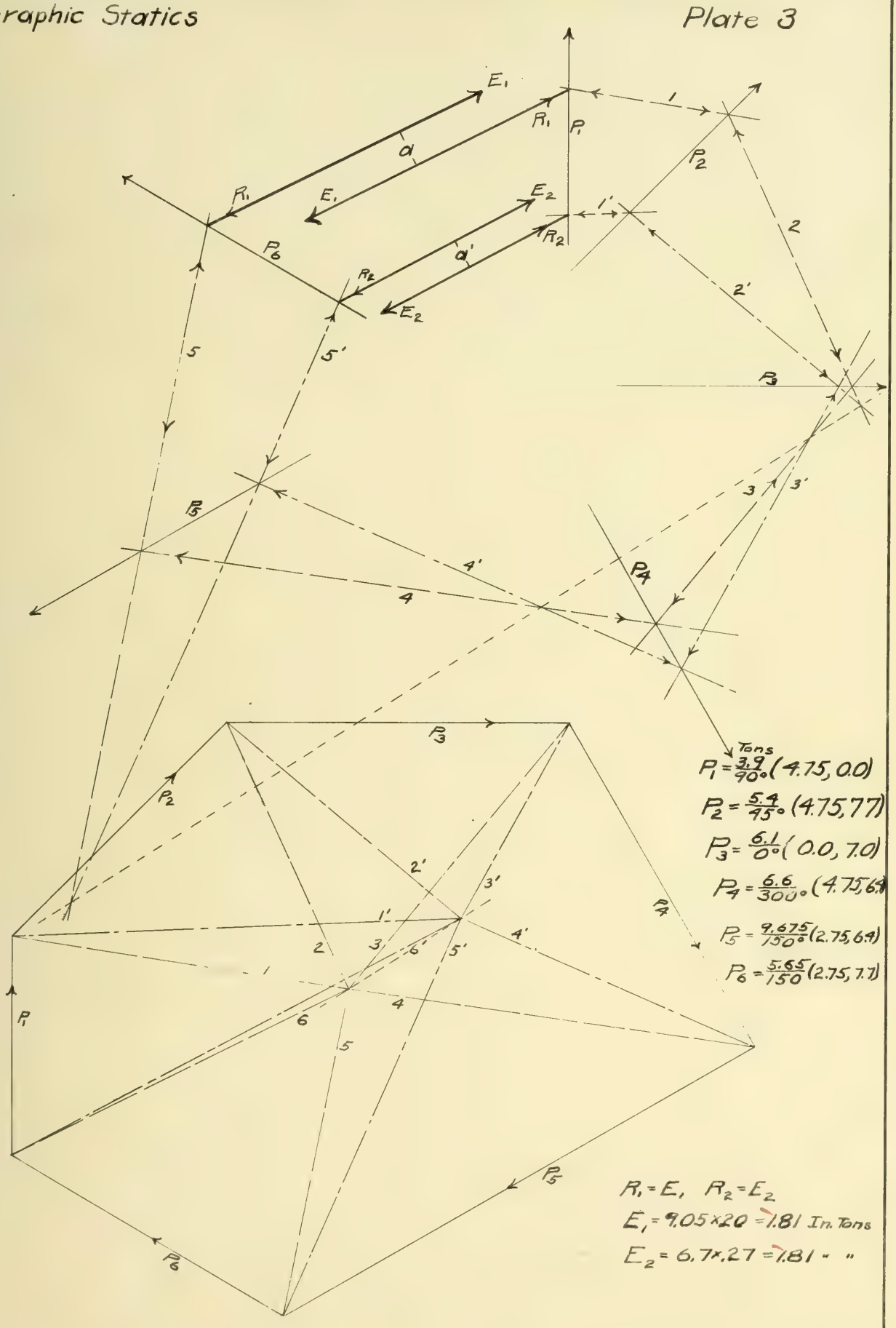
$R = \frac{487}{150^\circ 20'}$, Scaled



J. E. Shoemaker

Graphic Statics

Plate 3



$P_1 = \frac{3.9}{90^\circ}$ Tons (4.75, 0.0)

$P_2 = \frac{5.4}{45^\circ}$ (4.75, 7.7)

$P_3 = \frac{6.1}{0^\circ}$ (0.0, 7.0)

$P_4 = \frac{6.6}{300^\circ}$ (4.75, 6.4)

$P_5 = \frac{9.675}{150^\circ}$ (2.75, 6.4)

$P_6 = \frac{5.65}{150}$ (2.75, 7.7)

$R_1 = E_1$, $R_2 = E_2$

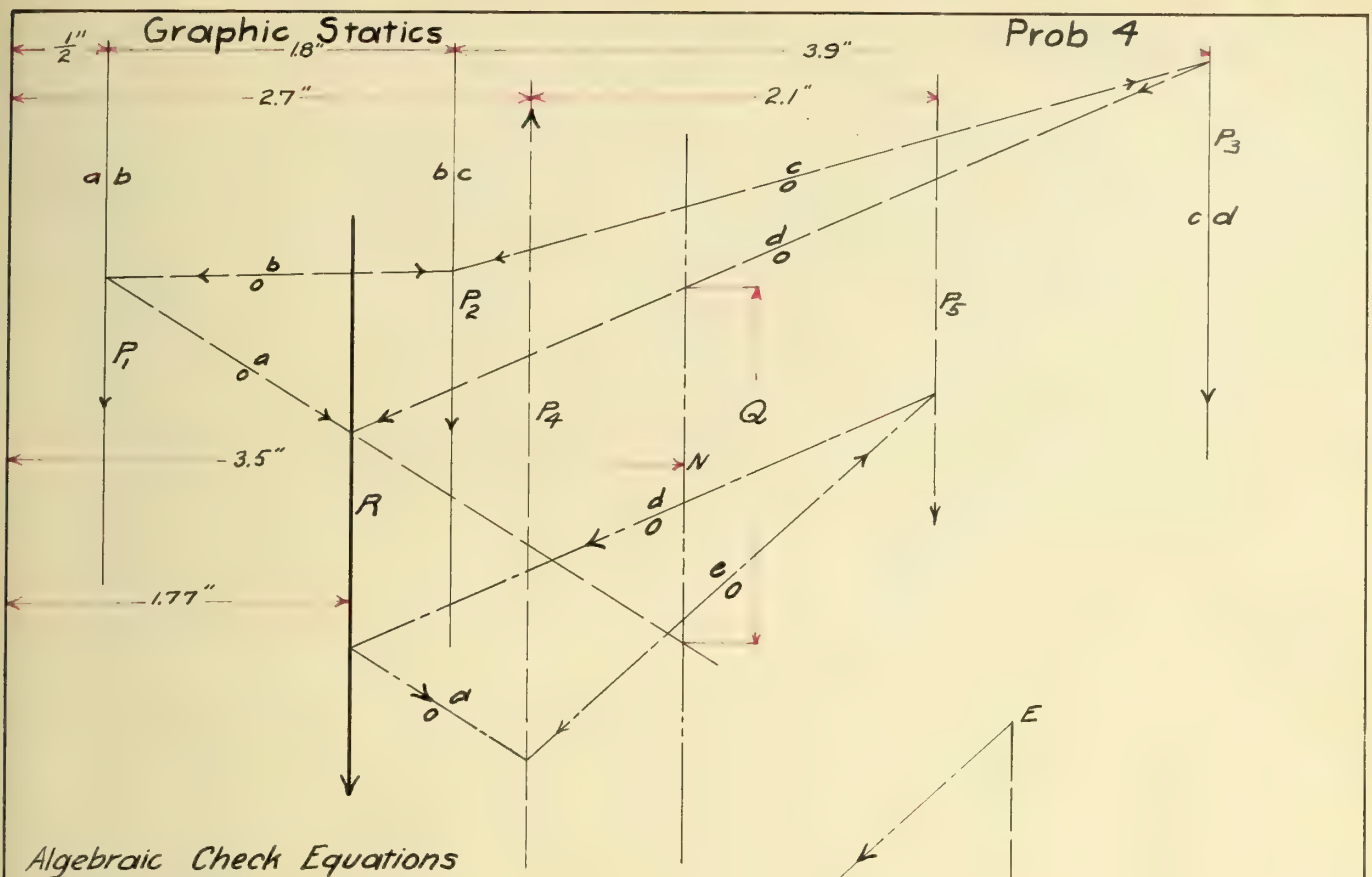
$E_1 = 9.05 \times 20 = 7.81$ In. Tons

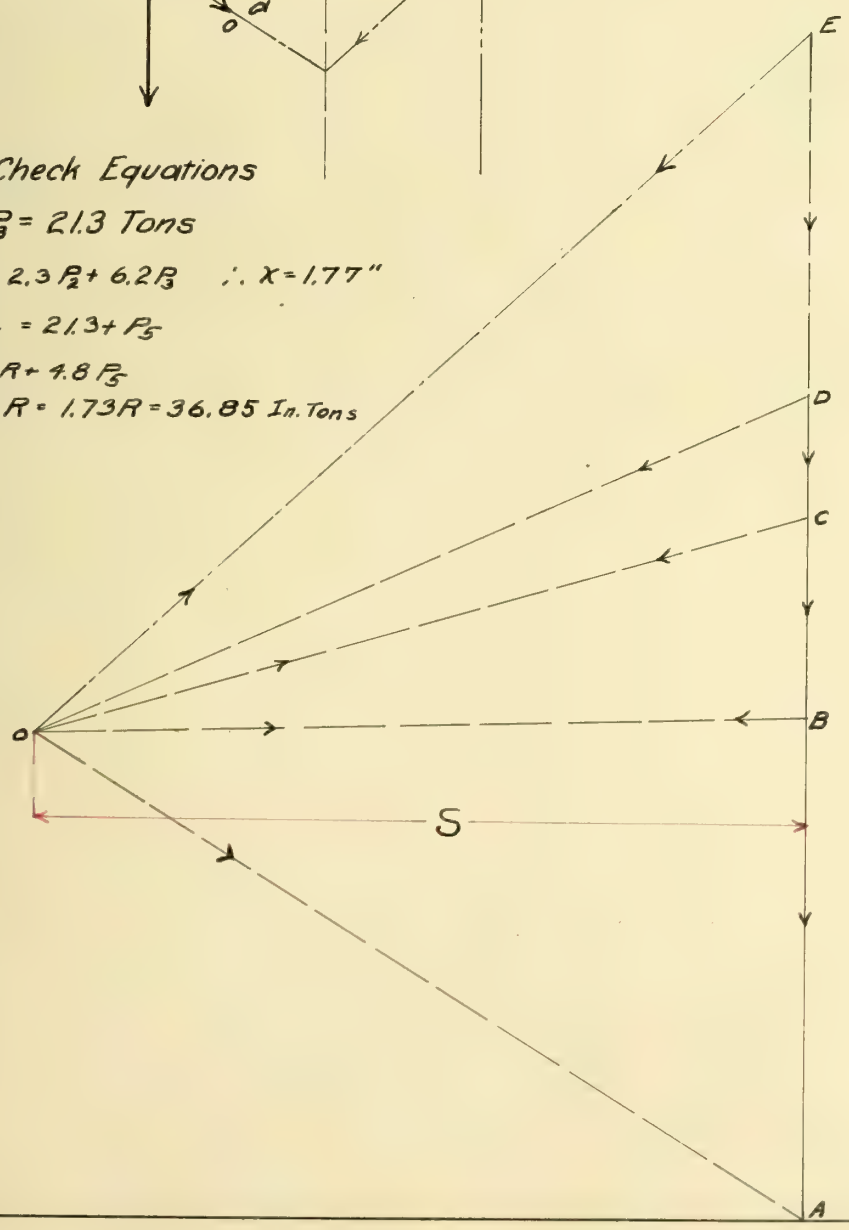
$E_2 = 6.7 \times 27 = 7.81$ " "

J. E. Sommater.

Graphic Statics

Prob 4





Algebraic Check Equations

$R = P_1 + P_2 + P_3 = 21.3$ Tons

$21.3\,x = \frac{1}{2}P_1 + 2.3\,P_2 + 6.2\,P_3 \quad \therefore x = 1.77''$

$$\begin{cases} P_4 = R + P_5 = 21.3 + P_5 \\ 2.7\,P_4 = 1.77\,R + 4.8\,P_5 \end{cases}$$

$M = (3.5 - x)\,R = 1.73R = 36.85$ In. Tons

$P_1 = 13.0$ T $\quad P_2 = 5.2$ T

$P_3 = 3.1$ T.

	Calculated	Scaled
R	21.3 T.	21.3
P_4	30.73	30.7
P_5	9.43	9.4
M	36.85 "T	36.84

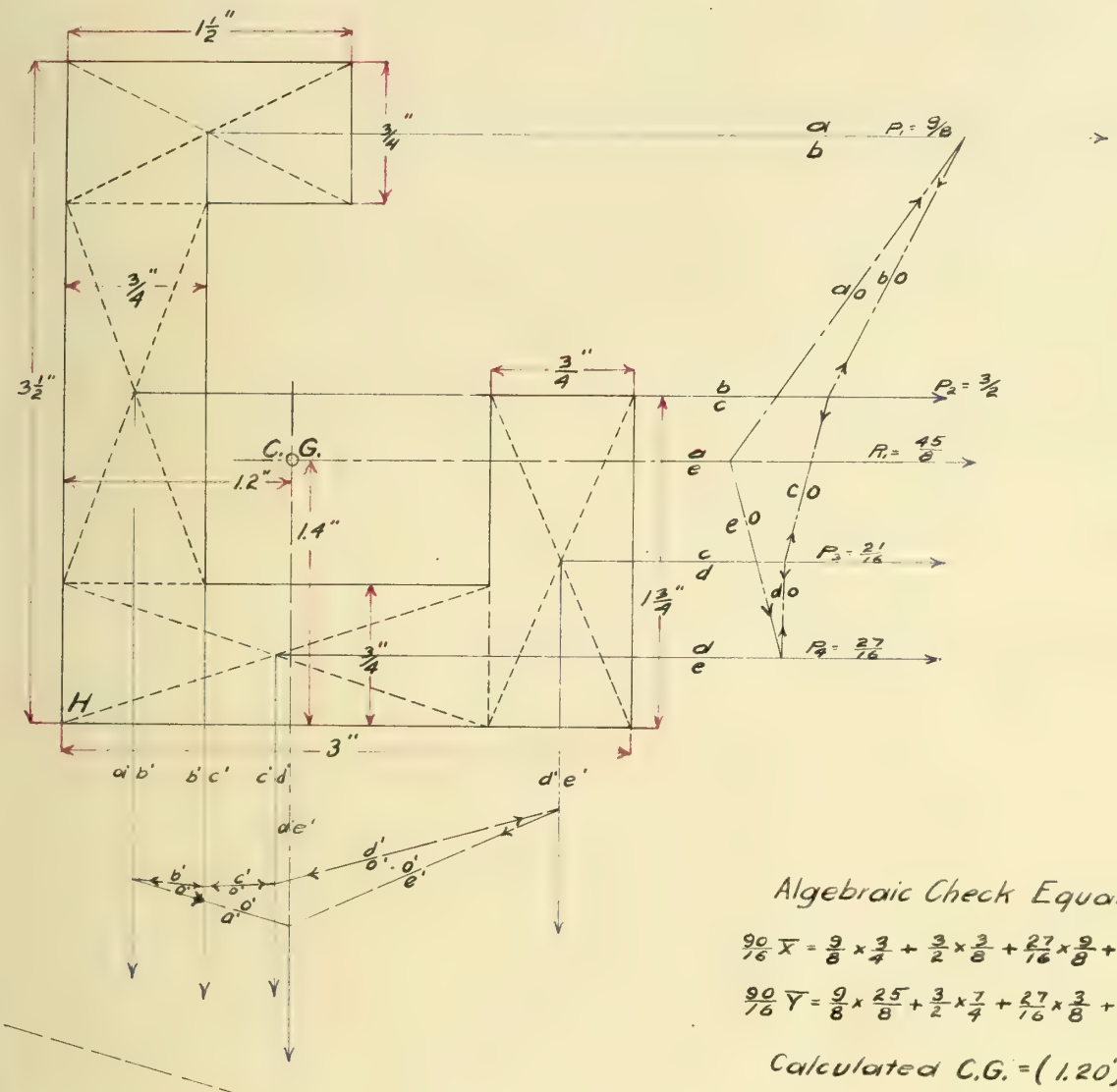
$M = Q \times S$

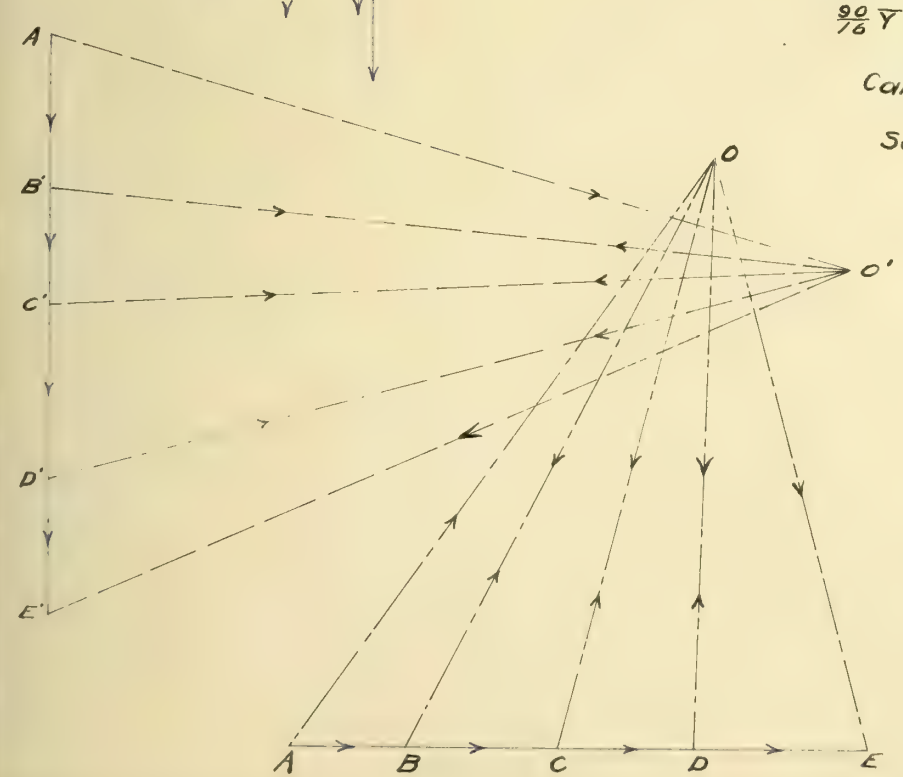
Scale 1" = 5 Tons

J. E. Shoemaker

Graphic Statics

Prob. 5





Algebraic Check Equations

$$\frac{90}{16}\bar{X} = \frac{9}{8}\times\frac{3}{4} + \frac{3}{2}\times\frac{3}{8} + \frac{27}{16}\times\frac{9}{8} + \frac{21}{16}\times\frac{21}{8}$$

$$\frac{90}{16}\bar{Y} = \frac{9}{8}\times\frac{25}{8} + \frac{3}{2}\times\frac{7}{4} + \frac{27}{16}\times\frac{3}{8} + \frac{21}{16}\times\frac{7}{8}$$

Calculated C.G. = (1.20", 1.41")

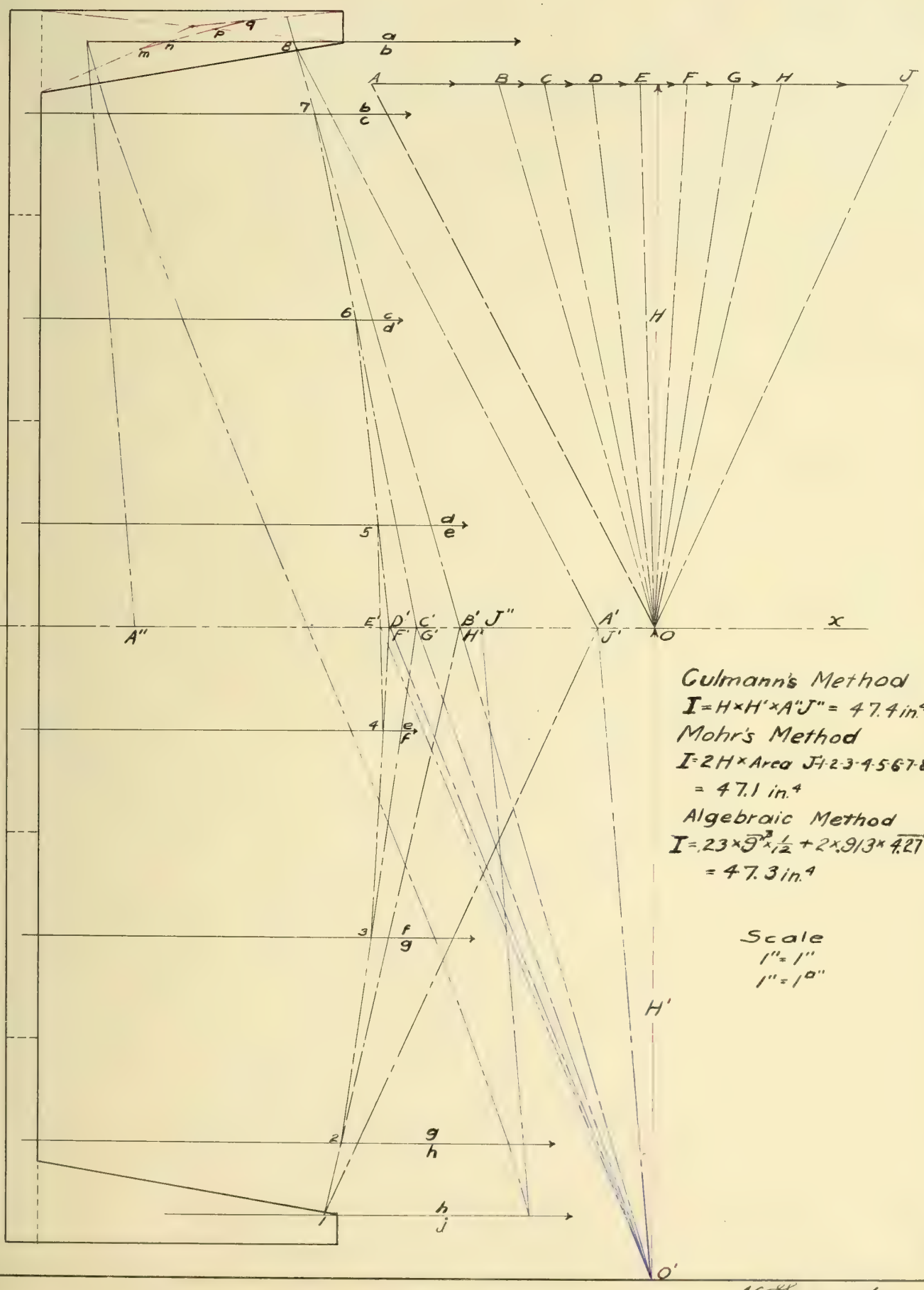
Scaled C.G = (1.20", 1.40")

Scale 1" = $1\frac{7}{8}$ sq. in Area

J. E. Shoemaker

Graphic Statics

Prob. 6



Culmann's Method

$I = H \times H' \times A''J'' = 47.4 \text{ in.}^4$

Mohr's Method

$I = 2H \times \text{Area } J\text{-}1\text{-}2\text{-}3\text{-}4\text{-}5\text{-}6\text{-}7\text{-}8$

$= 47.1 \text{ in.}^4$

Algebraic Method

$I = .23 \times \overline{9}^3 \times \frac{1}{12} + 2 \times .913 \times \overline{4.27}^2$

$= 47.3 \text{ in.}^4$

Scale

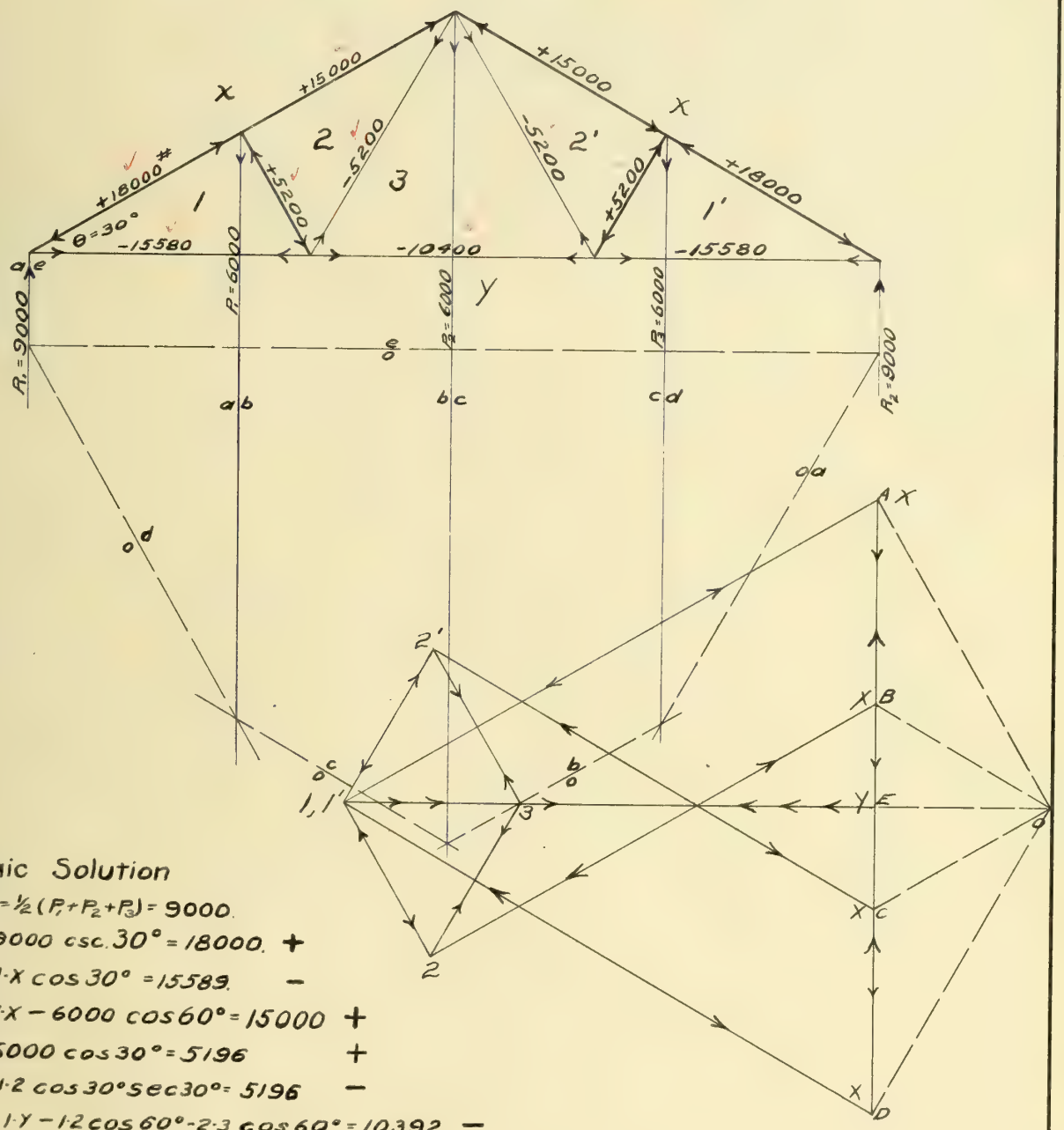
1" = 1"

1" = 10"

J. E. Thomaker

Graphic Statics

Prob 7



Algebraic Solution

$R_1 = R_2 = \frac{1}{2}(P_1 + P_2 + P_3) = 9000.$

$1\text{-}X = 9000 \csc 30° = 18000.$ +

$1\text{-}Y = 1\text{-}X \cos 30° = 15589.$ −

$2\text{-}X = 1\text{-}X - 6000 \cos 60° = 15000$ +

$1\text{-}2 = 6000 \cos 30° = 5196$ +

$2\text{-}3 = 1\text{-}2 \cos 30° \sec 30° = 5196$ −

$3\text{-}Y = 1\text{-}Y - 1\text{-}2 \cos 60° - 2\text{-}3 \cos 60° = 10392$ −

$3\text{-}2' = 3\text{-}2 \quad 2'\text{-}1' = 2\text{-}1 \quad 2'\text{-}X = 2\text{-}X \quad 1'\text{-}X = 1\text{-}X \quad 1'\text{-}Y = 1\text{-}Y$

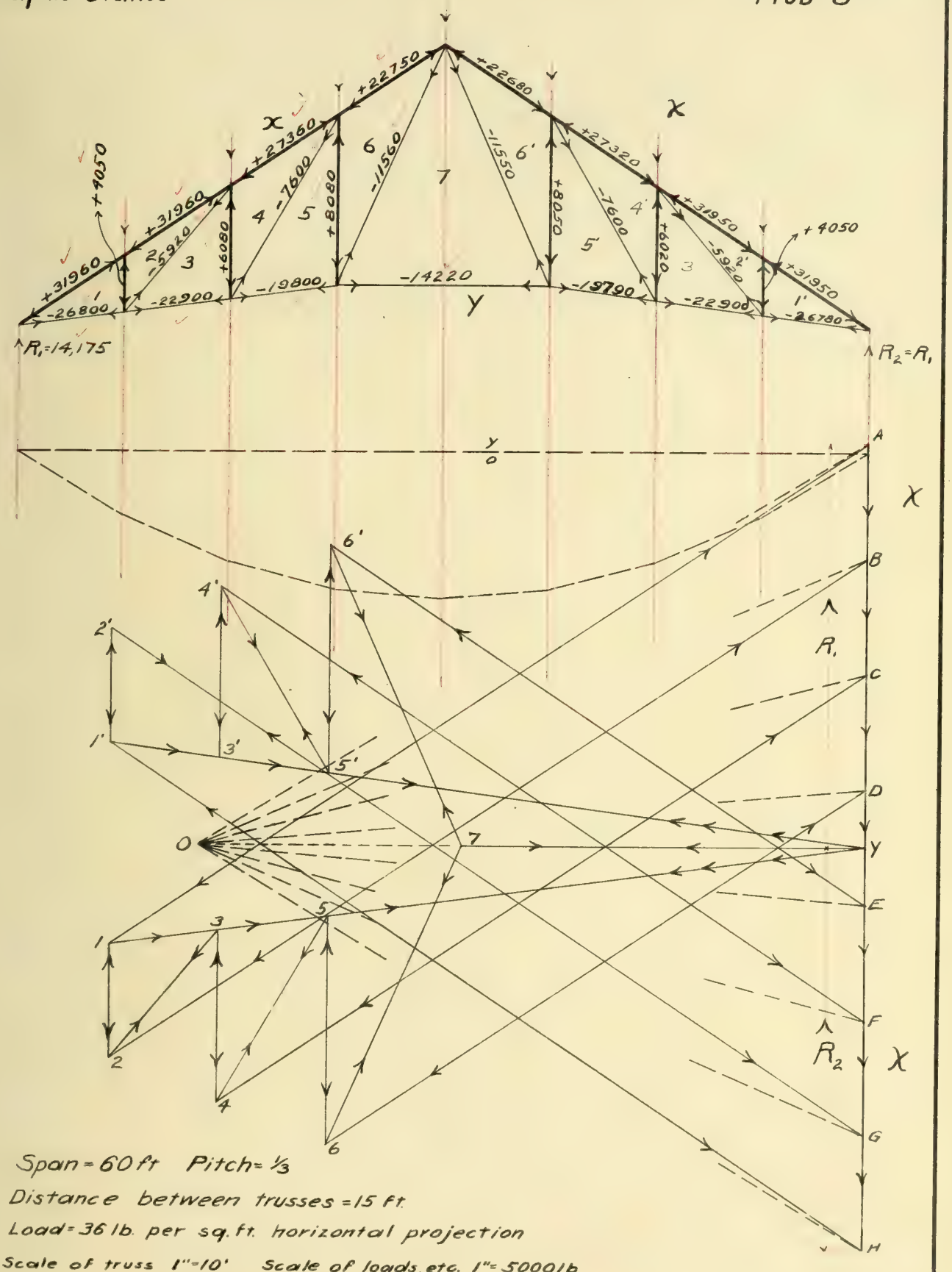
Scale for Truss 1" = 8' Scale for Loads 1" = 5000

40 ft Truss, spaced 15' c. to c.
Load = 40# per sq. ft. hor. proj.

J. E. Shoemaker

Graphic Statics

Prob 8



Span = 60 ft Pitch = 1/3

Distance between trusses = 15 ft.

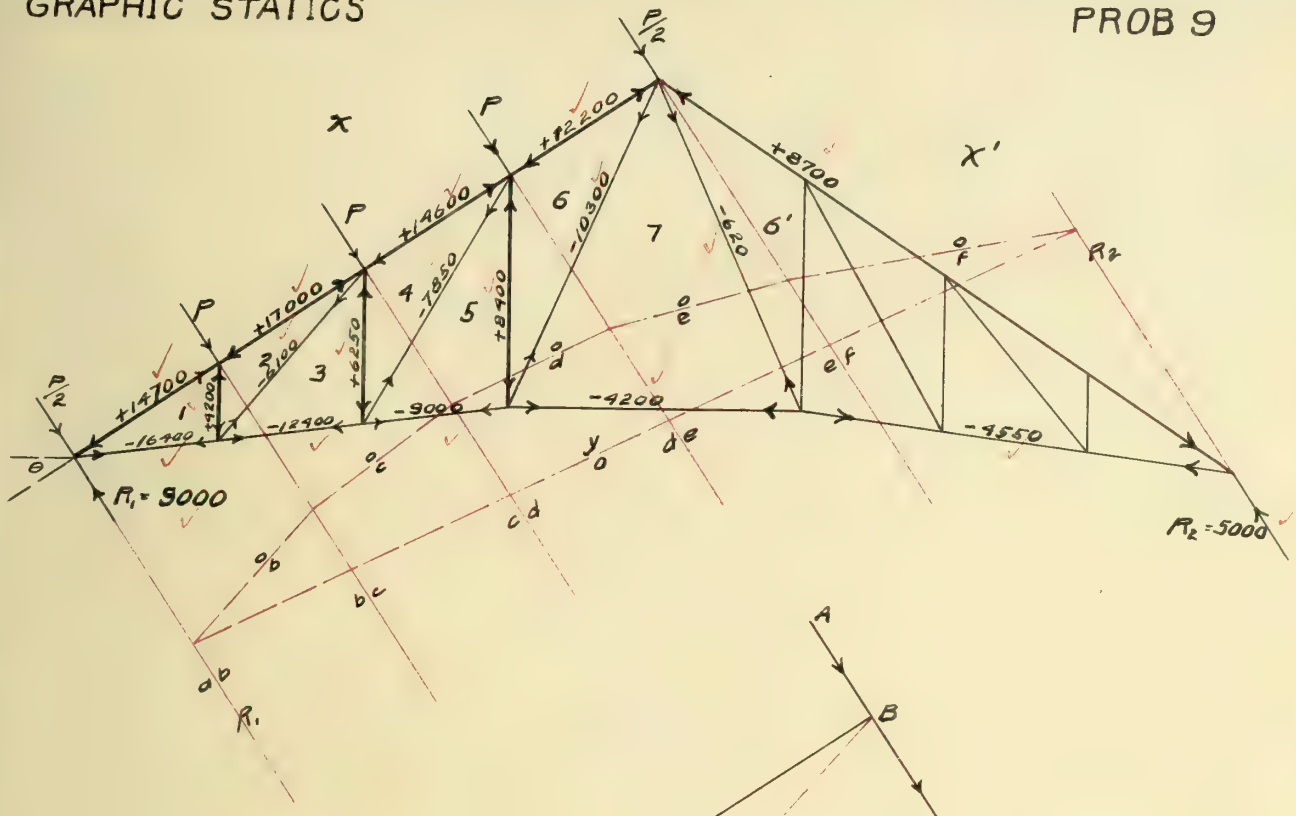
Load = 36 lb. per sq. ft. horizontal projection

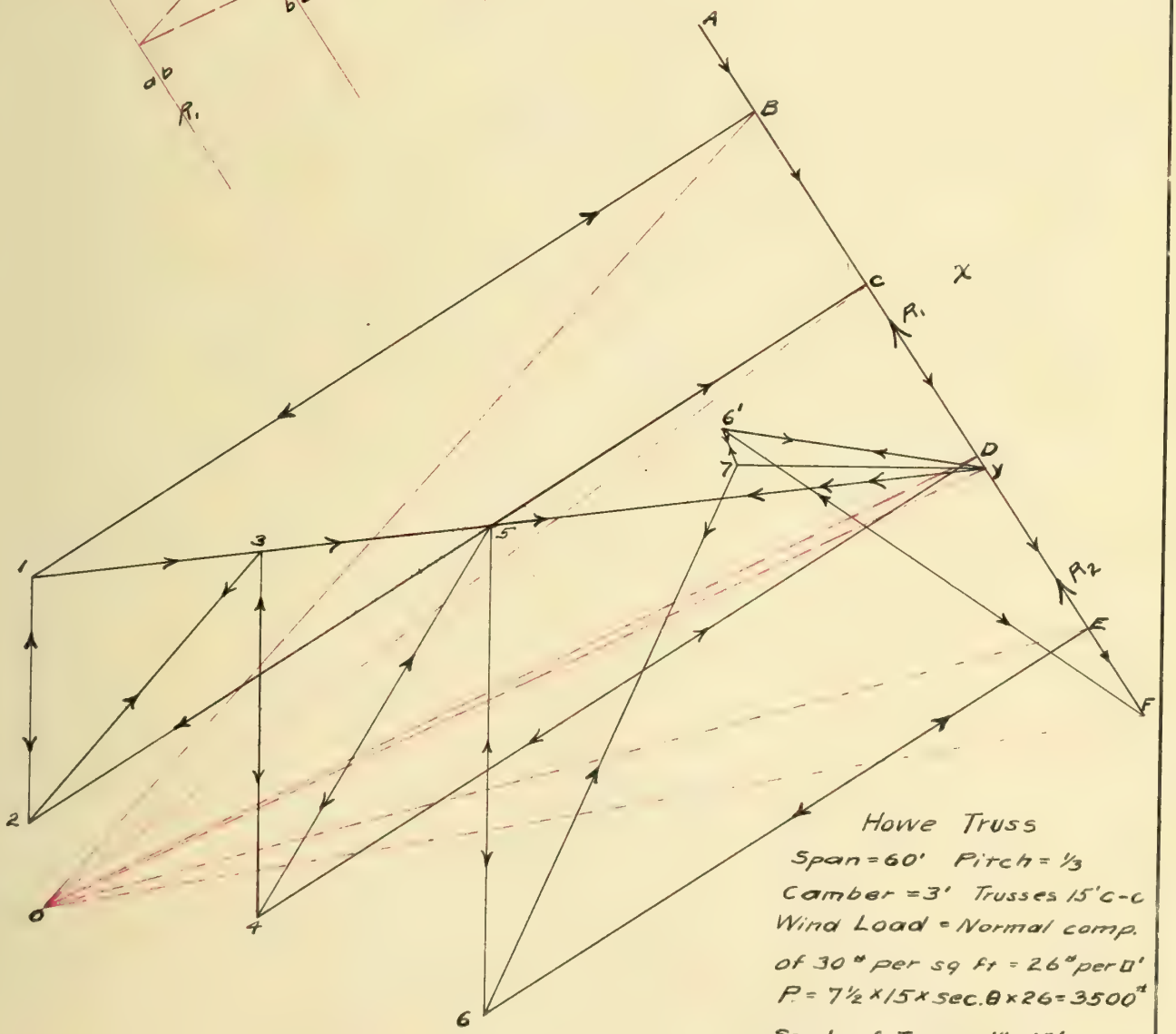
Scale of truss 1" = 10' Scale of loads, etc. 1" = 5000 lb

J. E. Shoemaker

GRAPHIC STATICS

PROB 9





Howe Truss

Span = 60' Pitch = 1/3

Camber = 3' Trusses 15' c-c

Wind Load = Normal comp. of 30# per sq ft = 26# per □'

P = 7½ × 15 × sec. θ × 26 = 3500#

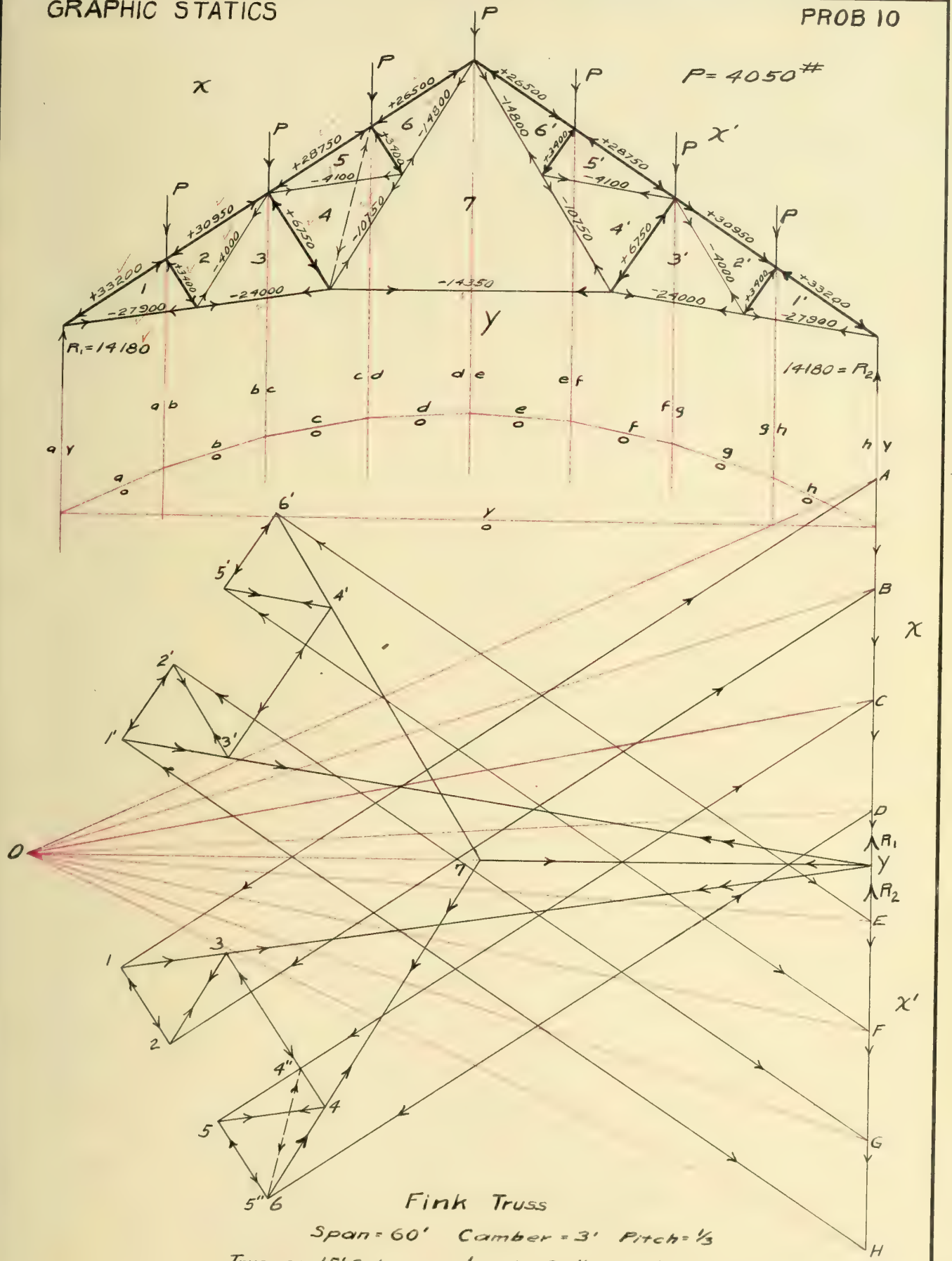
Scale of Truss 1" = 10'

Scale of Loads 1" = 3000#

J. E. Shoemaker

GRAPHIC STATICS

PROB 10



Fink Truss

Span = 60' Camber = 3' Pitch = 1/3

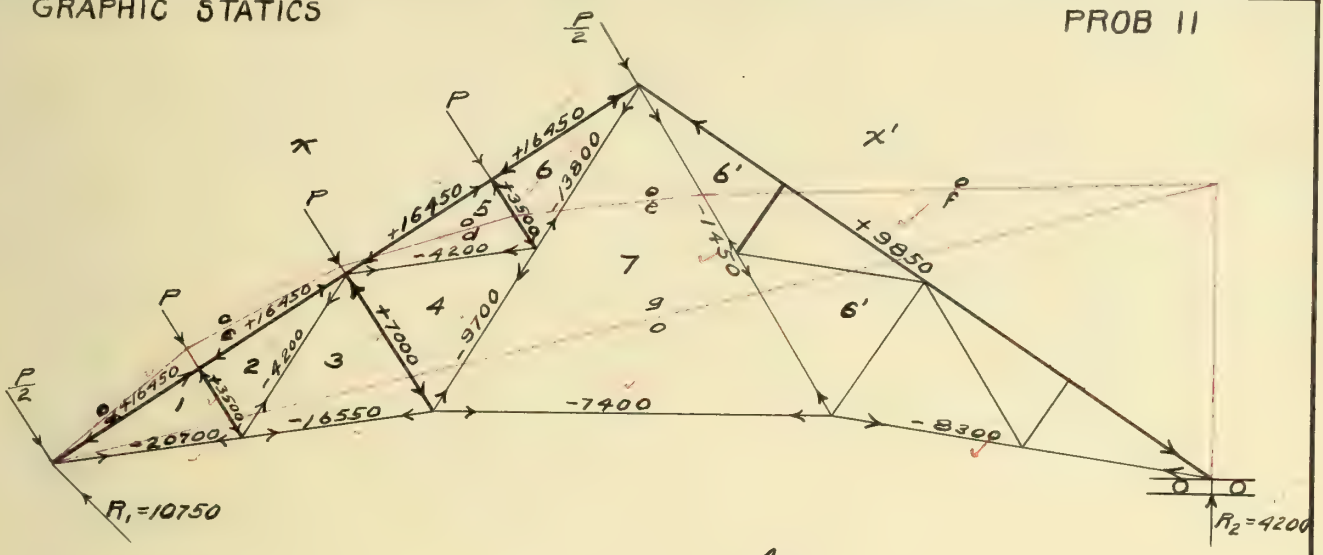
Trusses 15' c to c. Load = 36# sq ft. hor. proj.

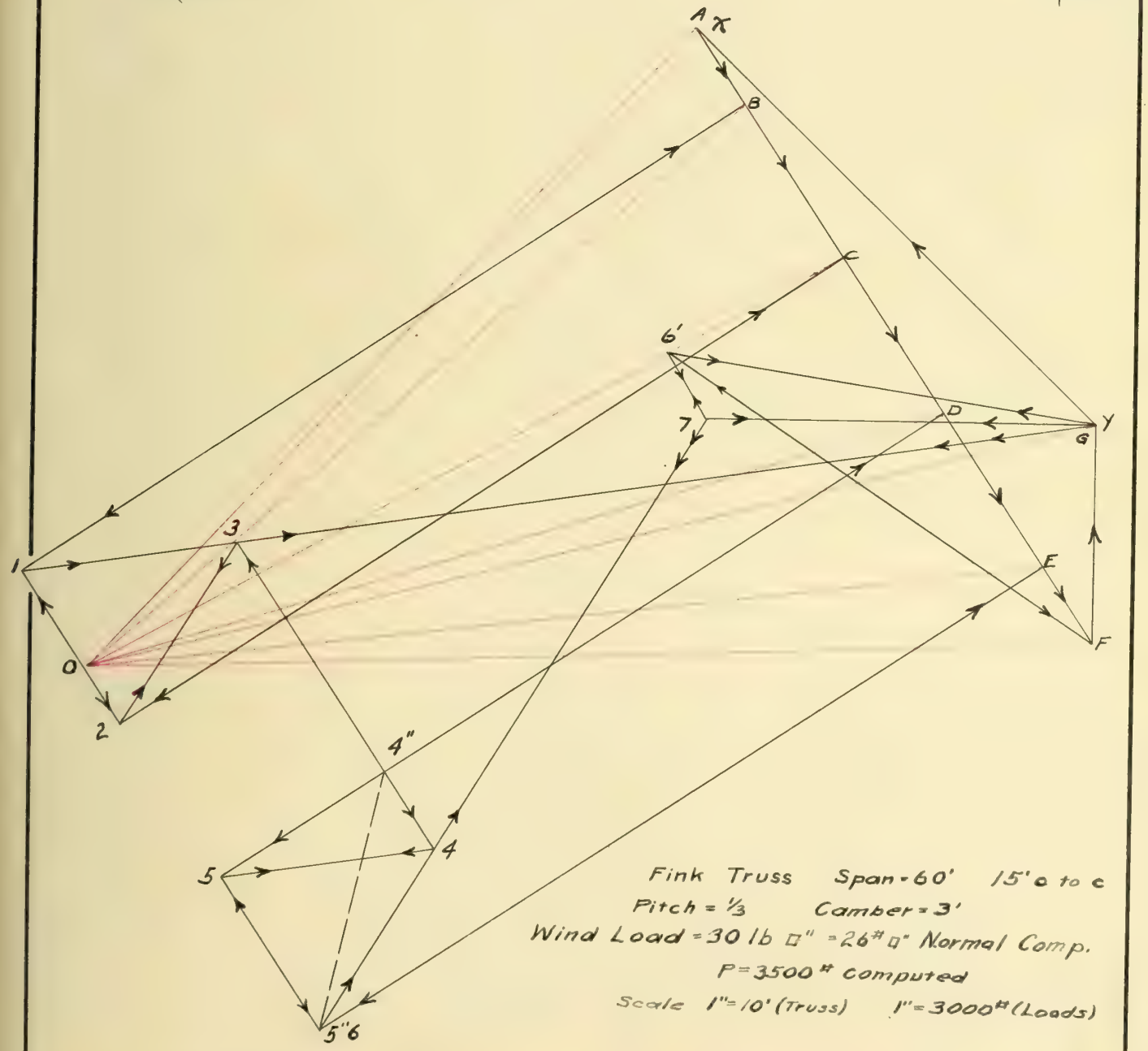
Scale of Truss 1" = 10' Scale of Loads 1" = 5000#

J. E. Thomason

GRAPHIC STATICS

PROB 11





Fink Truss Span = 60' 15' c to c

Pitch = 1/3 Camber = 3'

Wind Load = 30 lb □" = 26# □" Normal Comp.

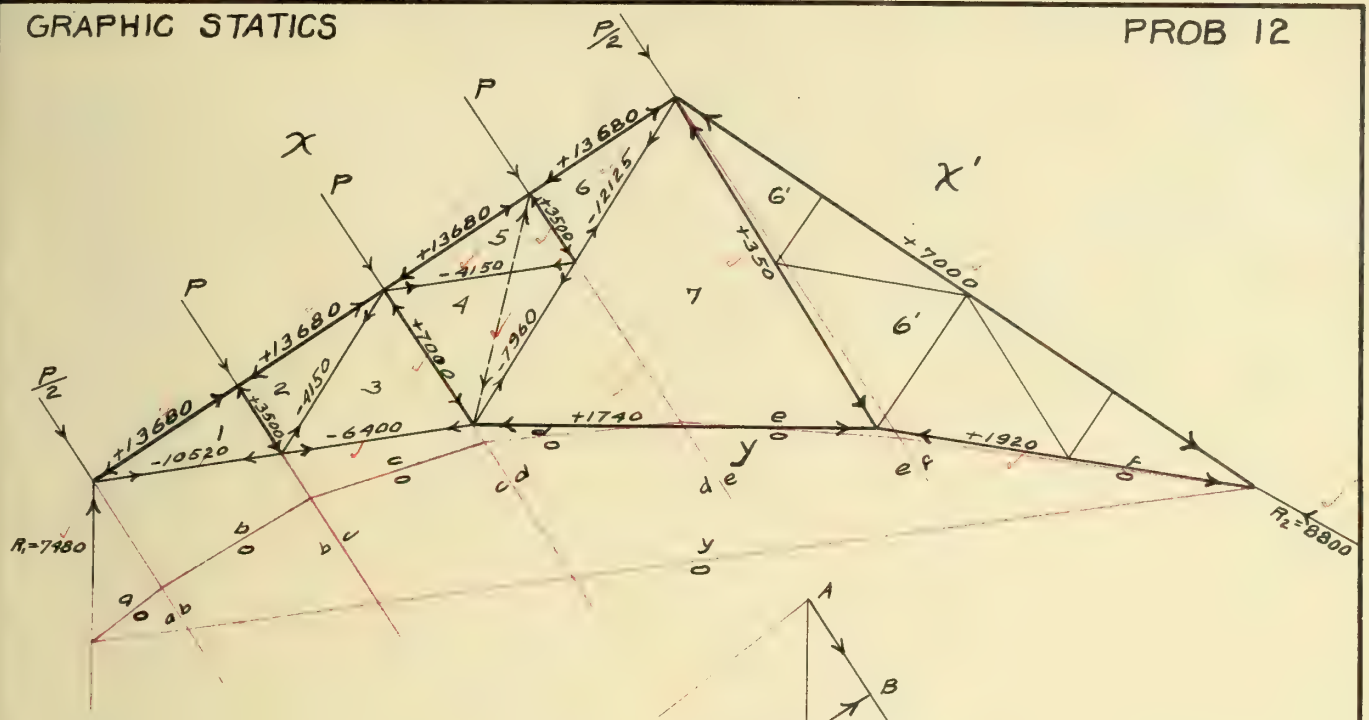
P = 3500# computed

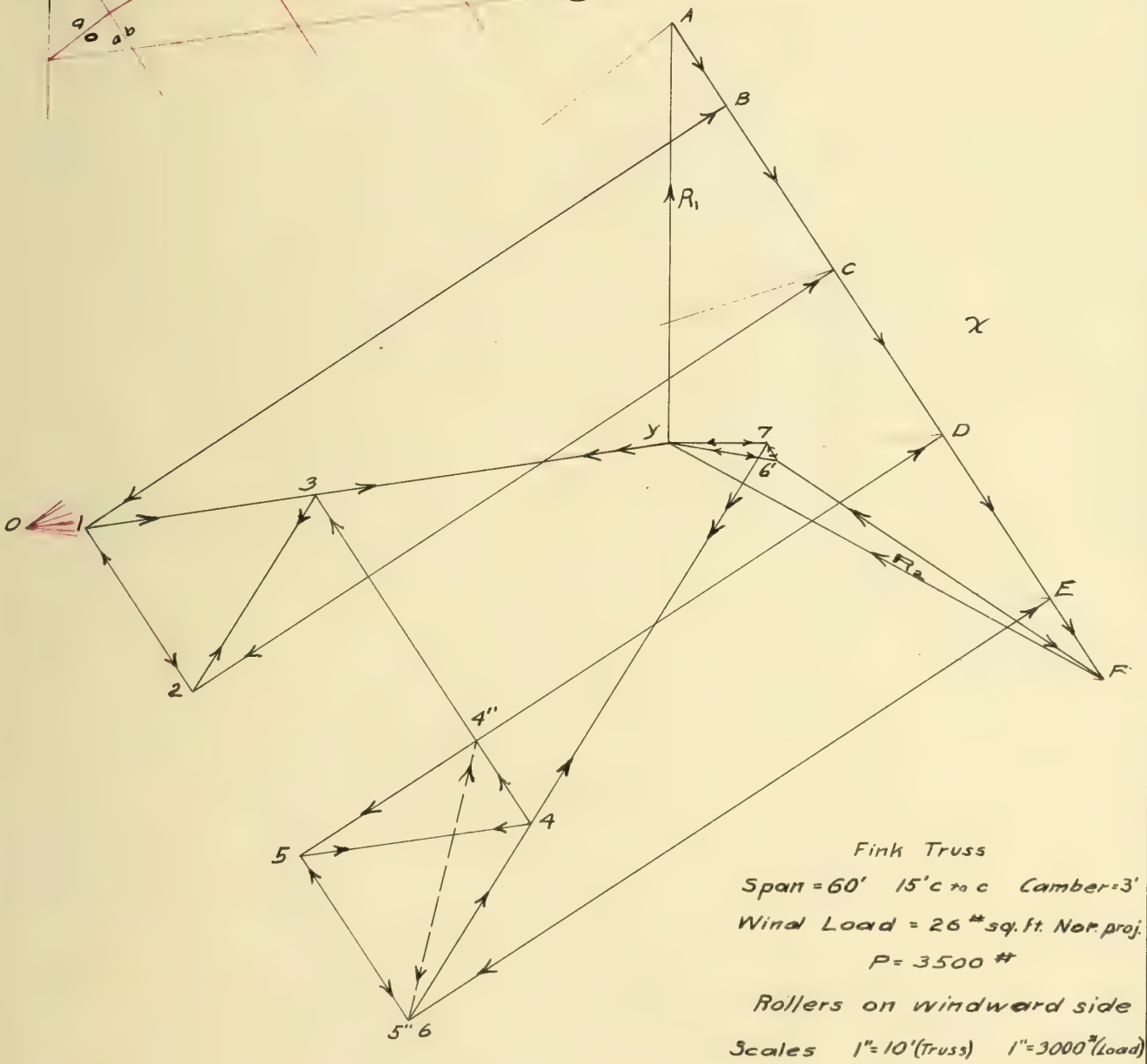
Scale 1" = 10' (Truss) 1" = 3000# (Loads)

J E Shoemaker

GRAPHIC STATICS

PROB 12





Fink Truss

Span = 60' 15' c to c Camber = 3'

Wind Load = 26 # sq. ft. Nor. proj.

P = 3500 #

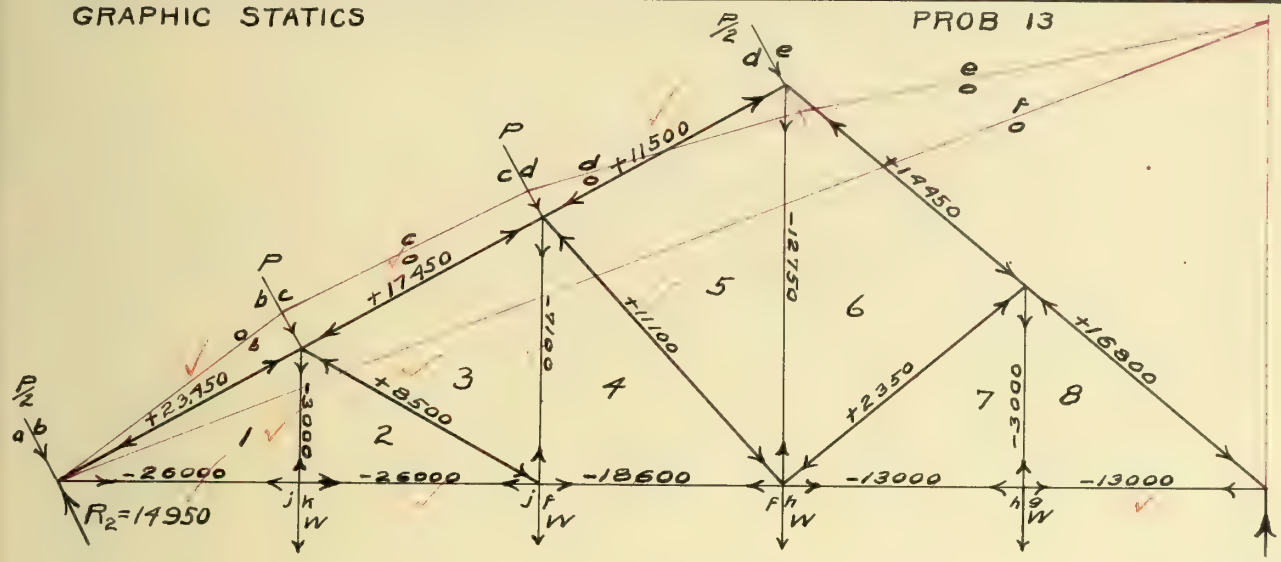
Rollers on windward side

Scales 1" = 10' (Truss) 1" = 3000 # (Load)

J. E. Shoemaker

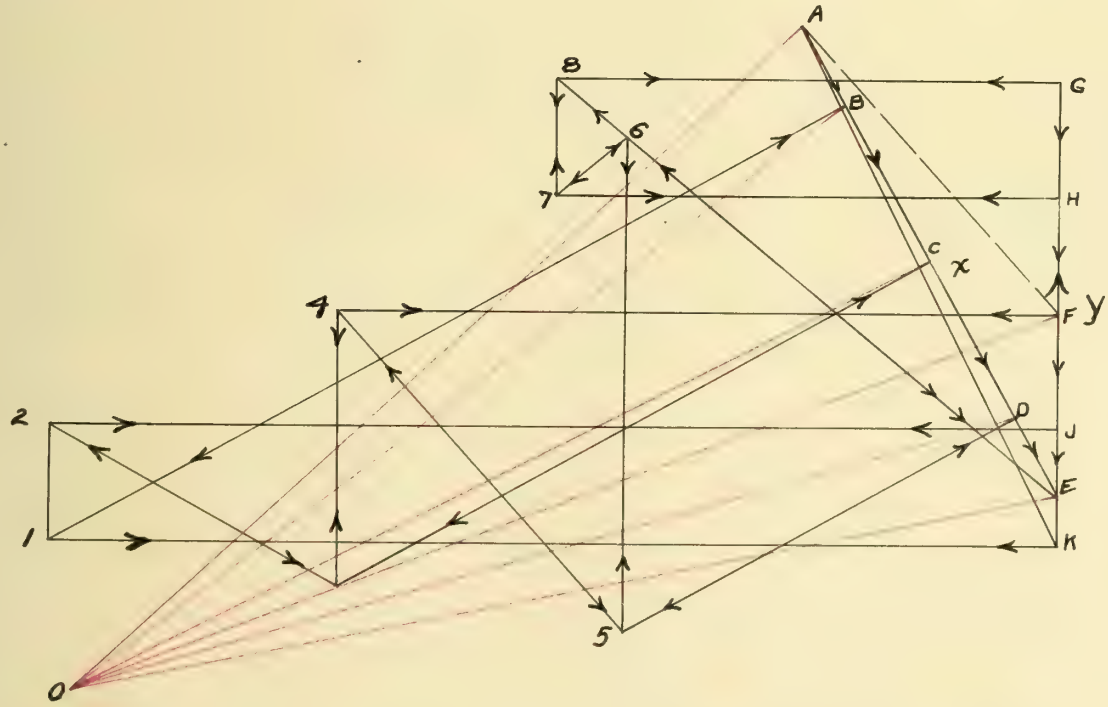
GRAPHIC STATICS

PROB 13



P = 4600#
W = 3000#

R_1 = 7700



$R_1' = EF$
$R_2' = FA$
$R_1 = EG$
$R_2 = KA$

Span of Truss = 50'

Height of Truss = 16 2/3'

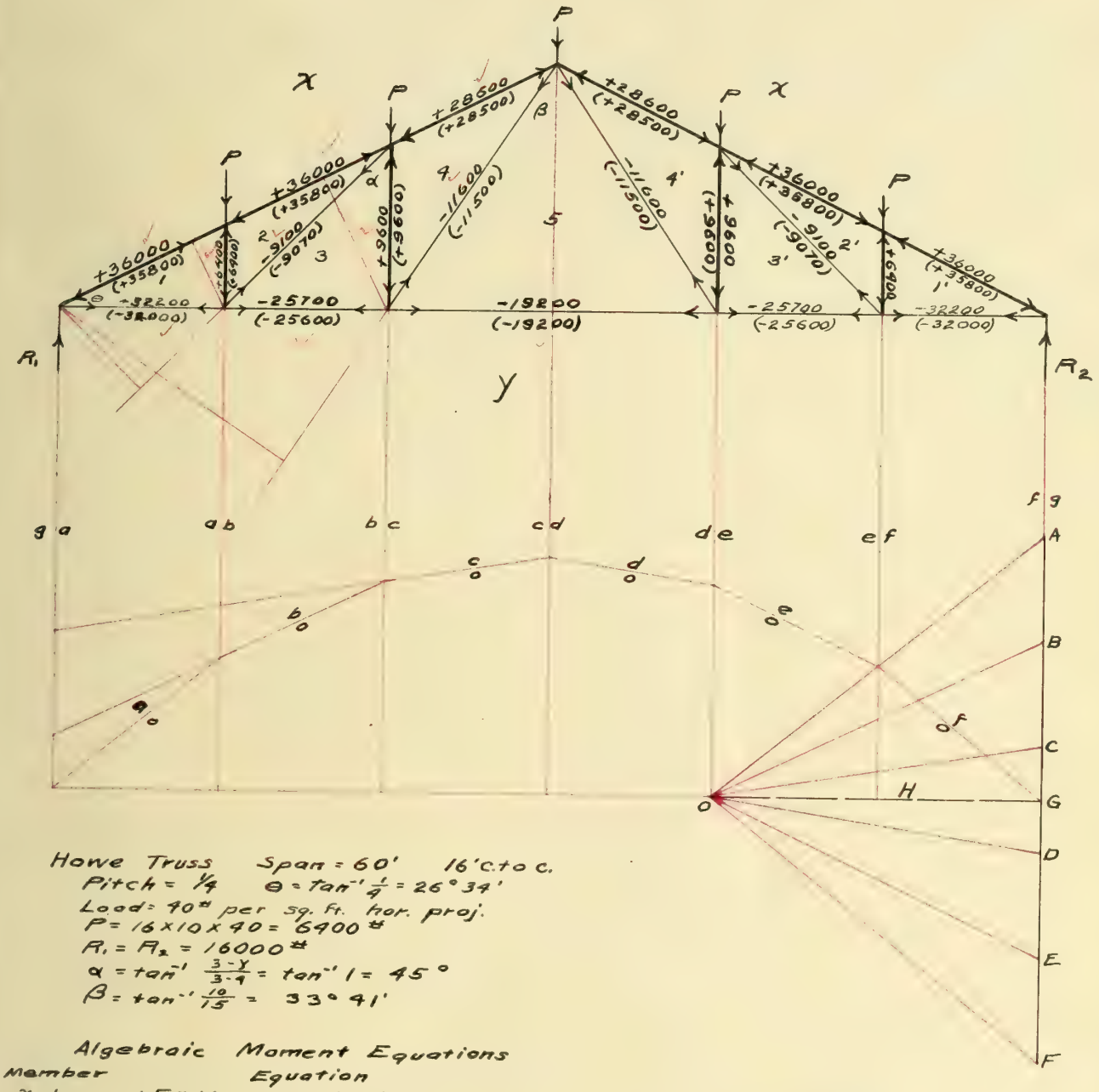
Scale of Truss 1" = 8'

Scale of Loads 1" = 5000#

J. E. Shoemaker

GRAPHIC STATICS

PROB 14



Howe Truss Span = 60' 16 c.to c.

Pitch = 1/4 $\theta = \tan^{-1}\frac{1}{4} = 26°34'$

Load = 40# per sq. Ft. hor. proj.

$P = 16 \times 10 \times 40 = 6400\#$

$R_1 = R_2 = 16000\#$

$\alpha = \tan^{-1}\frac{3-y}{3-4} = \tan^{-1} 1 = 45°$

$\beta = \tan^{-1}\frac{10}{15} = 33°41'$

Algebraic Moment Equations

Member	Equation
x-1	$+F_1 \times 10 \sin\theta - R_1 \times 10 = 0$
y-1	$-F_2 \times 10 \tan\theta - R_1 \times 10 = 0$
1-2	$+F_3 \times 10 - P \times 10 = 0$
x-2	$+F_4 \times 10 \sin\theta - R_1 \times 10 = 0$
2-3	$-F_5 \times 20 \sec\theta \cos(\alpha+\theta) - P \times 10 = 0$
3-y	$-F_6 \times 20 \tan\theta + P \times 10 - R_1 \times 20 = 0$
3-4	$+F_7 \times 20 - P \times 10 - P \times 20 = 0$
4-x	$+F_8 \times 20 \sin\theta + P \times 10 - R_1 \times 20 = 0$
4-5	$-F_9 \times 30 \sec\theta \cos(\theta+\beta) - P \times 10 - P \times 20 = 0$
5-y	$-F_{10} \times 15 - R_1 \times 30 + P \times 10 + P \times 20 = 0$

$F_1 = +35800$

$F_2 = -32000$

$F_3 = +6400$

$F_4 = +35800$

$F_5 = -9070$

$F_6 = -25600$

$F_7 = +9600$

$F_8 = +2850$

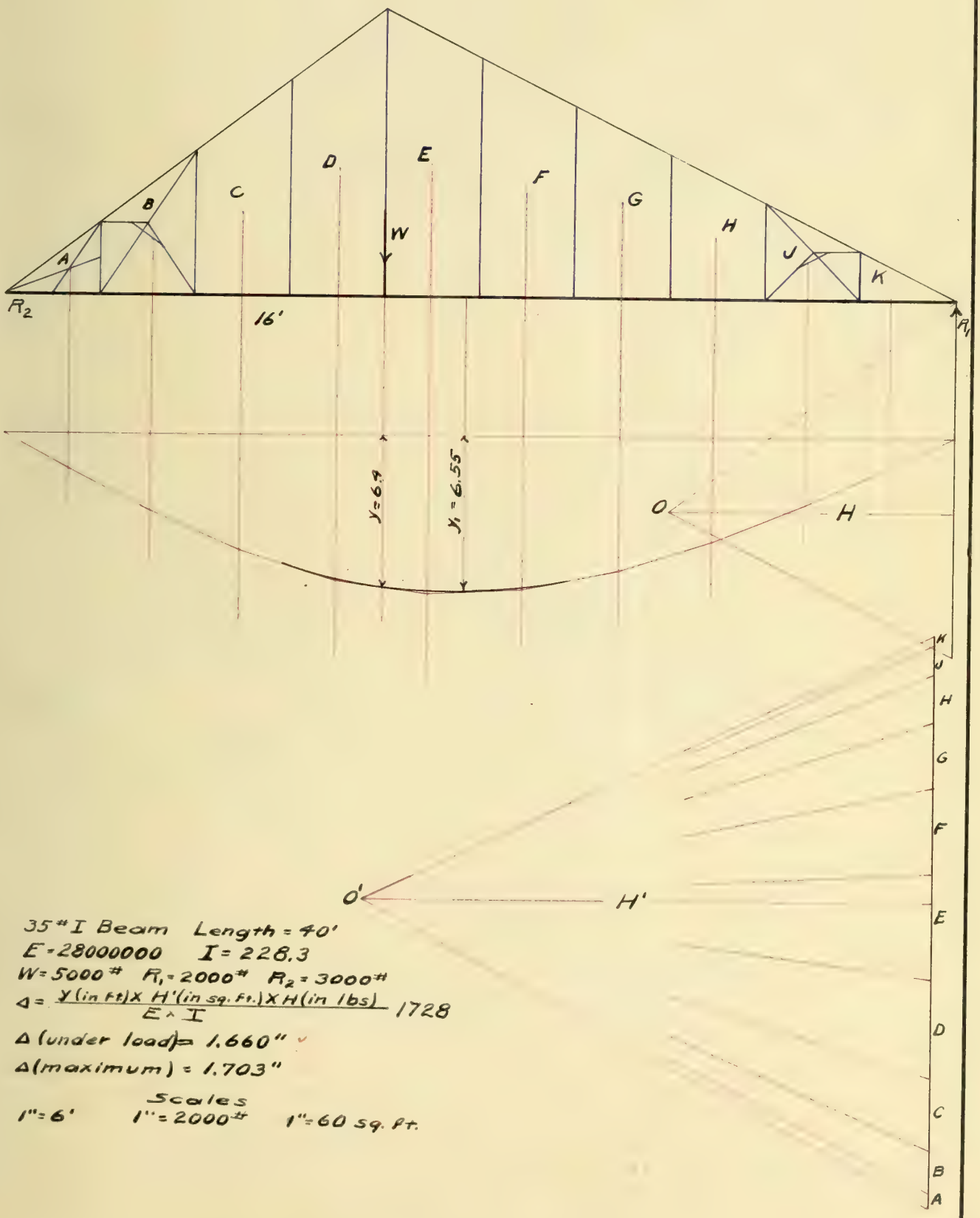
$F_9 = -11500$

$F_{10} = -19200$

J. E. Thomason

GRAPHIC STATICS

PROB 15



35# I Beam Length = 40'

E = 28000000 I = 228.3

W = 5000# R_1 = 2000# R_2 = 3000#

$$\Delta = \frac{Y\text{ (in Ft)} \times H'\text{ (in sq. Ft.)} \times H\text{ (in lbs)}}{E \times I} \quad 1728$$

Δ (under load) = 1.660"

Δ (maximum) = 1.703"

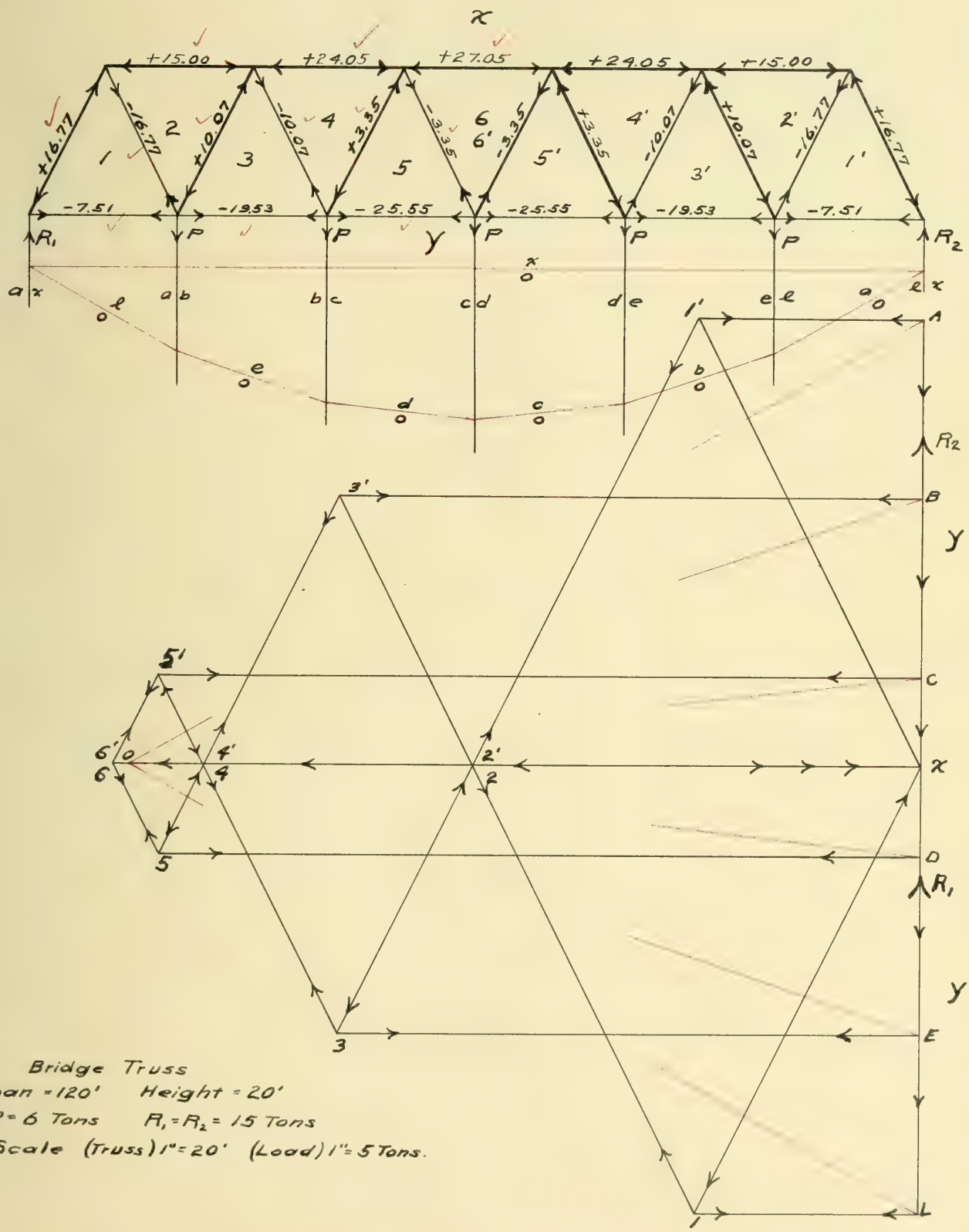
Scales

1" = 6' 1" = 2000# 1" = 60 sq. Ft.

J E Shoemaker

GRAPHIC STATICS

PROB 16



Bridge Truss

Span = 120' Height = 20'

P = 6 Tons $R_1 = R_2 = 15$ Tons

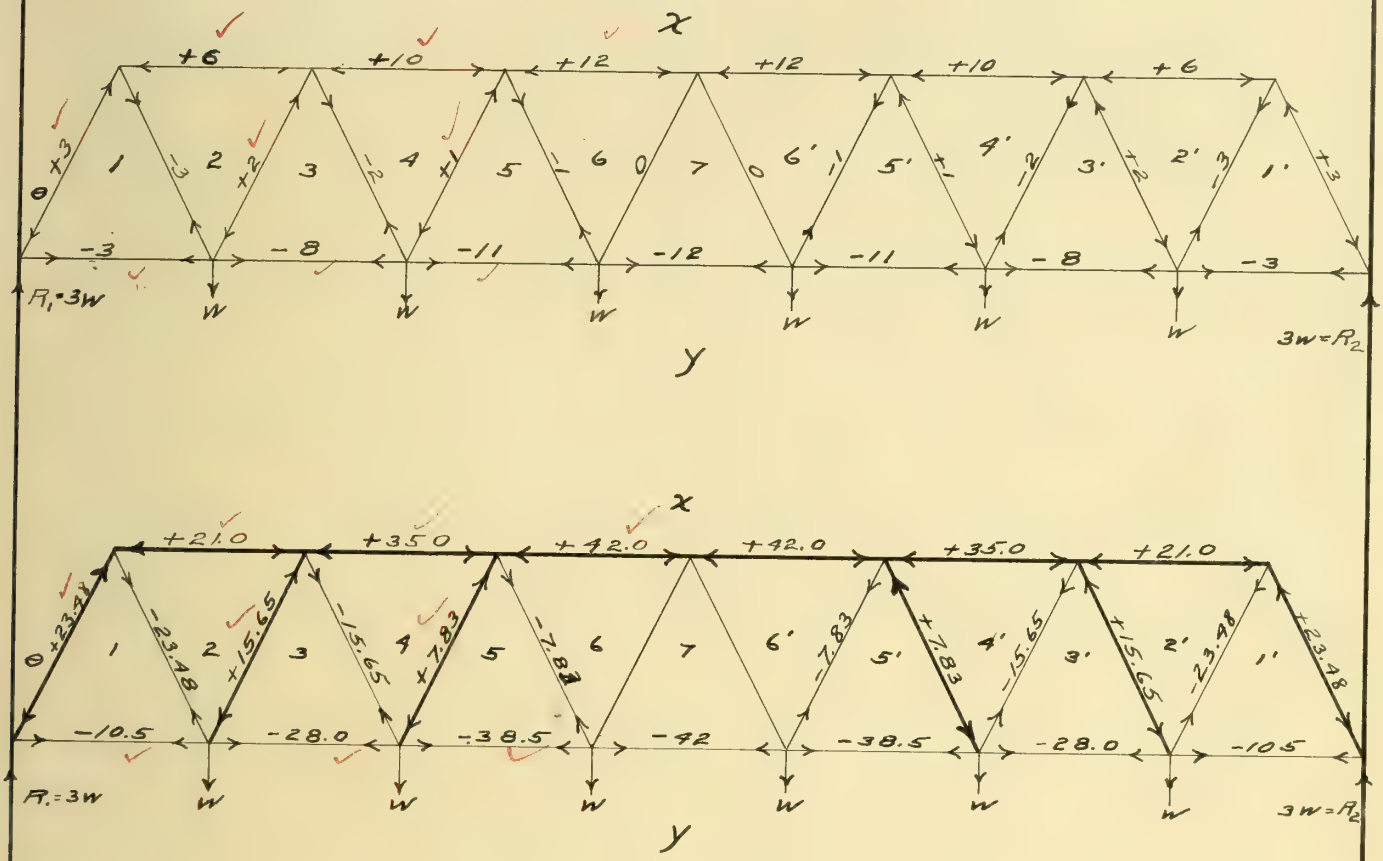
Scale (Truss) 1" = 20' (Load) 1" = 5 Tons.

J. E. Shoemaker

MAY 20

GRAPHIC STATICS

PROB 17



Warren Truss

Span = 140' Height = 20' Number of Panels = 7

Stress in Web Members = Coef. x W sec θ

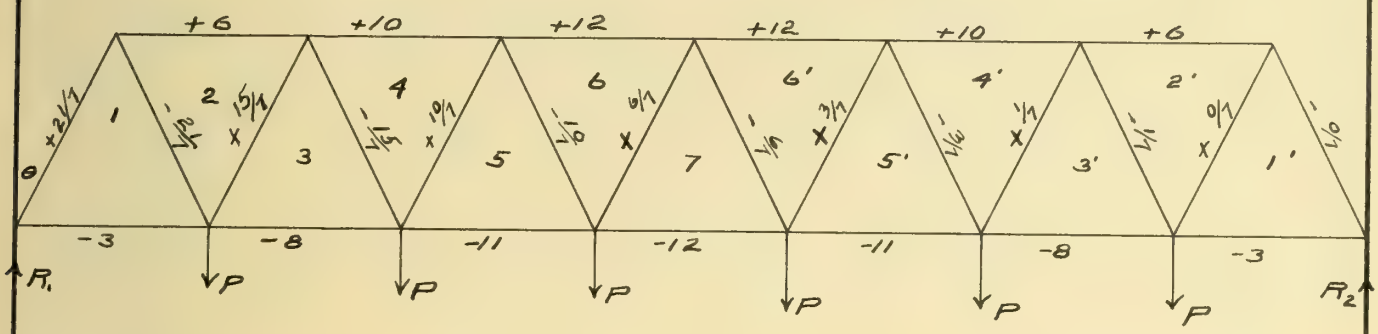
Stress in Chord Members = Coef. x W tan θ

W = 7 Tons $\tan\theta = \frac{1}{2}$ $\sec\theta = \frac{\sqrt{5}}{2} = 1.118$

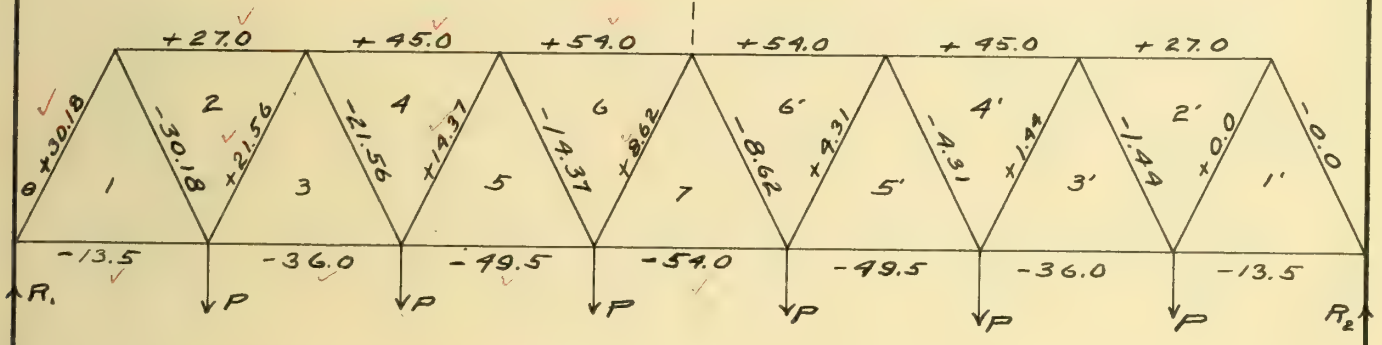
Scale 1" = 20' $R_1 = R_2 = 3W = 21$ Tons.

J. E. Shoemaker

GRAPHIC STATICS PROB 18



Maximum Web Stresses | Minimum Web Stresses



Warren Truss

Length = 140' Height = 20' Panel Length = 20'

P = 9 Tons Live Load $\theta = \tan^{-1} \frac{1}{2}$ $\sec \theta = 1.118$

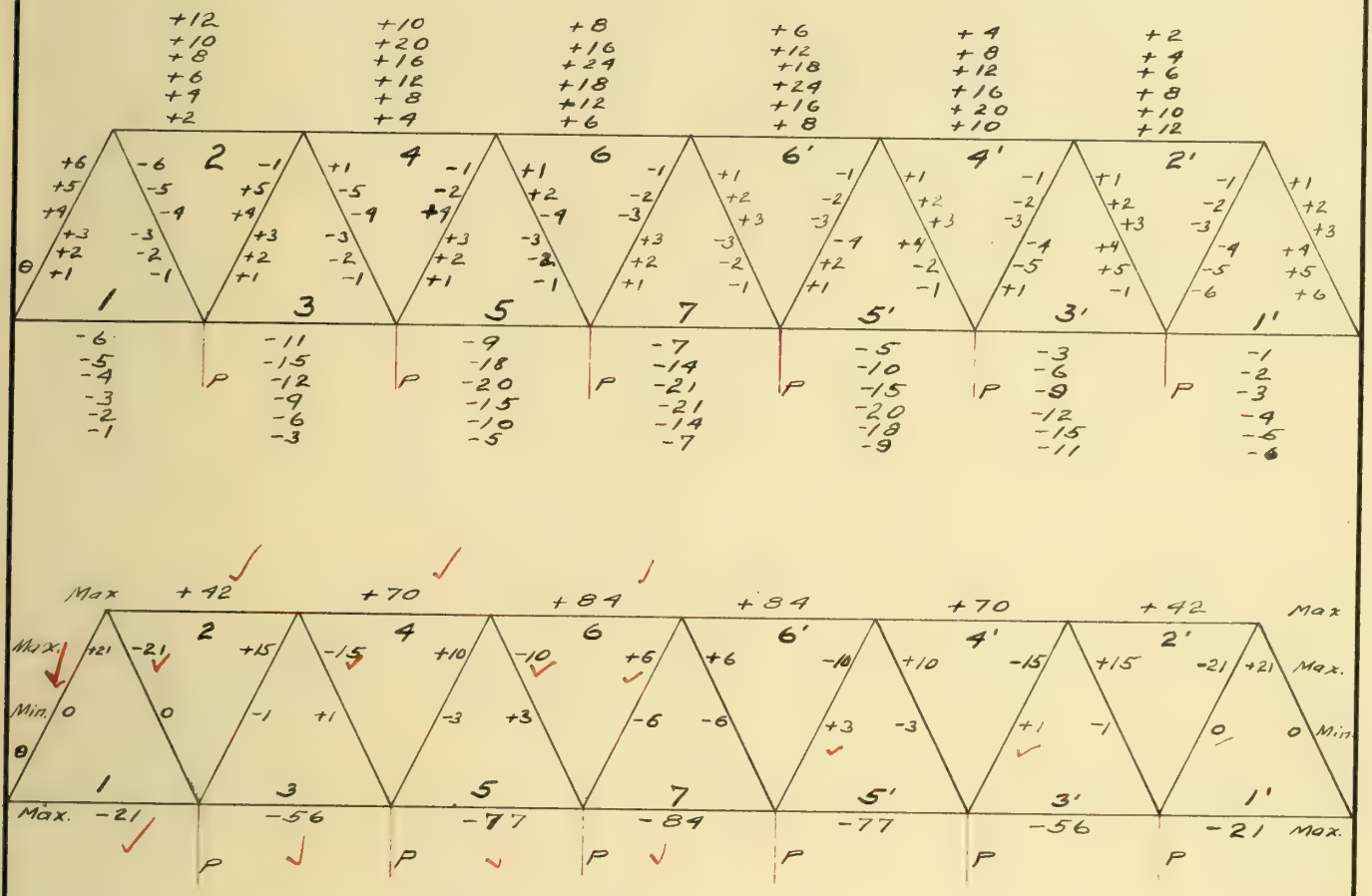
Web Stresses = Coef. x P sec θ. P sec θ = 10.06 Tons

Chord Stresses = Coef. x P tan θ P tan θ = 4.5 Tons

J E Shoemaker

GRAPHIC STATICS

PROB 19



Warren Truss

Span = 140' Height = 20' Length of Panel = 20' No. of Panels = 7

Stresses due to live loads. Loads applied one at a time.

Also maximum and minimum stresses. Min. chord stresses = 0

Stress in chord member = Coef. $\times \frac{1}{7} P \tan\theta = \frac{1}{7} \times \frac{P}{2}$ $\tan\theta = \frac{1}{2}$

Stress in web member = Coef. $\times \frac{1}{7} P \sec\theta = \frac{1}{7} P \times 1.118$ $\sec\theta = 1.118$

Scale 1" = 20'

J. E. Shoemaker

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